1 Introduction

The vision for Plurigrid is a globally unified computing system where all resources are represented as objects in a distributed file system, accessible via a uniform naming scheme. This provides location independence, flexibility, and extensibility. A hierarchical namespace organizes objects and offers a simple yet powerful way to structure the system. Capability-based access controls enable fine-grained management of resources.

Personal accounts give users ownership over their digital environments. Locally scoped resources balance global access with direct control. Together, these principles enable a system that is at once transparently distributed yet meaningfully human-centered.

Plurigrid concepts provide a blueprint for realizing this vision. Plurigrid services would allow diverse devices, protocols, and interfaces to interoperate to varying degrees based on their needs. Rather than a single operating system, Plurigrid facilitates the gradual integration of shared system-level functions that diverse applications can build upon.

New devices would implement Plurigrid capabilities as modules, exposing interoperable interfaces. Over time, different architectures and protocols adopt Plurigrid services, enabling global coordination while preserving localized dynamics. This balances individual agency and emergence with scalable segmentation, access management, and global optimization.

While Plurigrid represents a global computing system and circular economy, its aim is to provide individuals with tools to make sense of and act in the world through automated agents that negotiate across scales. These agents maximize Nash equilibria while preserving user agency and preferences.

2 A Category Theoretic Framing

We can frame Plurigrid as a braided monoidal category, with:

- Objects: Representing resources (compute processes, data, models, devices) and users.
- Morphisms: Representing the interactions and exchanges between objects, such as trading resources for $GRID$ tokens or accessing resources through capabilities.
- Composition: The ability to compose morphisms by linking inputs and outputs, enabling complex computations and value generation.
- Braiding: The ability for morphisms to cross over each other, representing how resources can be shared and combined in different orders to unlock new value.
- Monoidal structure: A "tensor" product $\otimes$ that combines objects, representing how resources can be bundled, nested, or aggregated together.

This category theoretic framing provides a mathematical model for understanding how Plurigrid enables:

- Resource circulation: Where the outputs of one process become the inputs of another through the composition of morphisms, maximizing efficiency.
- Value generation: Where new objects and morphisms emerge through the creative recombination and braiding of existing ones.
- Scalable complexity: Where simple objects and morphisms can be combined into more complex ones through the monoidal tensor product.

Plurigrid automates the "rewriting" of this category by:

- Tracking resource usage and transactions to enable new metrics for efficiency and value.
- Using mutual credit and $GRID$ tokens to fund new object/morphism generation.
- Distributing ownership/access rights to enable exchange and recombination.
- Incentivizing contributions that maximize circulation, value, and access.

This category theoretic perspective provides a formal foundation for understanding how Plurigrid can facilitate a global circular economy powered by open, distributed flows of resources and value generation.

3 Compositional Open Games and Emergence

The interactions between users, resources, and agents in Plurigrid can be modeled as a compositional open game, with:

- Players: Representing users, resources, and automated agents.
- Strategies: Representing how players access, exchange, and combine resources to generate value.
- Payoffs: Representing how value is distributed among players, such as through $GRID$ token exchanges, NFT sales, and mutual credit.
- Composition: Where the strategies and payoffs of "child" games determine those of "parent" games, enabling complex interactions to emerge from simple ones.

Through the interplay of various players employing different strategies at different scales, a decentralized form of governance and control emerges that balances individual agency with global coordination. This emergence results from:

- Resource sharing: Where players exchange resources through strategies that maximize access and value for whole populations.
- Value alignment: Where the payoffs received by players depend on maximizing the well-being and flourishing of other players.
- Scalable decentralization: Where localized "child" games operate autonomously while linking up into more complex "parent" games.
- Feedback loops: Where the outcomes of strategies at one scale influence the strategies employed at other scales.

This compositional game theoretic framing provides a model for understanding how Plurigrid can facilitate the emergence of a sustainable digital society where people generate and exchange resources to solve meaningful problems together in a spirit of open collaboration.

4 Transitioning to a Circular Economy

A circular economy is one where resources are continuously cycled to maximize value and minimize waste. Plurigrid enables a global circular economy for computing resources by:

- Tracking resource usage and transactions transparently and persistently as objects/morphisms in its distributed file system.
- Facilitating resource exchanges for $GRID$ tokens, distributing resources to where they are most productive and needed.
- Using mutual credit to fund new resource generation where potential value is collateral for loans, unlocking new value creation without scarce funds.
- Capturing surplus resource value as bounty, funding further refinement. This creates a self-sustaining loop where value generates more value.
- Distributing ownership/access rights to resources as NFTs, enabling value realization through the exchange, recombination, and continuous refinement.
- Incentivizing contributions maximizing resource efficiency, utility, and access. Plurigrid monitors resource usage to minimize waste and maximize social benefits.

Transitioning to a circular economy requires:

- New metrics for value: Beyond narrow economic measures to include social, environmental, and creative benefits. Plurigrid provides transparent records enabling new metrics for sustainability and well-being.

- Alternative ownership models: Where access and capability are distributed, not concentrated. Plurigrid's NFTs and personal accounts enable shared resource ownership, unlocking community value.
- Regulatory frameworks: Encouraging circularity, e.g. extended producer responsibility, right-to-repair, and pollution pricing. Regulations must adapt to ensure Plurigrid's resource exchanges comply with laws.
- Changes in behavior: Where people and businesses maximize resource efficiency and access. Plurigrid drives change through pricing signals, rewards, and gamification, but transitioning mindsets require education.
- Investment in infrastructure: Renewable energy systems, public transportation, and sustainable agriculture. Plurigrid coordinates and optimizes infrastructure to maximize access and circularity.

With the right metrics, models, regulations, behaviors, and infrastructure, Plurigrid can facilitate transitioning to a sustainable circular economy unlocking new value for humanity. But this requires public/private cooperation to reshape systems and transition mindsets societally.

5 Decentralized Identity and Power Fingerprinting

In Plurigrid, users establish a decentralized identity by generating a unique ID and public/private key pair. The ID is used to associate resources, capabilities, and transactions with a user's personal account. The public key enables other users to verify the user's identity and sign transactions.

Users can generate subkeys for specific contexts, e.g. work vs. personal. This allows for compartmentalizing resources and activities. Users control which subkeys and capabilities are disclosed in each context.

Power fingerprinting analyzes a user's resource usage, transactions, and other activity to generate a "fingerprint" representing their relative influence and capability within the network. This fingerprint can be used to determine a user's eligibility for loans, governance rights, and other privileges. It provides a decentralized measure of reputation and trustworthiness.

Power fingerprinting must preserve privacy by using zero-knowledge proofs and other techniques. Users choose which aspects of their activity are disclosed for fingerprinting. They can generate multiple fingerprints for different contexts.

Decentralized identity and power fingerprinting provide the foundations for an open, privacy-preserving system of mutual credit and governance. They enable determining a user's "creditworthiness" and system privileges in a decentralized manner while giving users control over their data.

6 User Experience and Applications

The Plurigrid user experience centers around a personal workspace - a portal for accessing resources, generating value, and engaging with the broader network. The workspace includes:

- A dashboard summarizing the user's power fingerprint, resource usage, transactions, notifications, and other activity. Users can customize which data is displayed.
- A file manager for navigating the distributed file system. Users can upload/download files, launch applications, and manage resources. Capabilities determine which resources/applications a user can access.
- A marketplace for exchanging resources, collaborating, and conducting transactions with other users. This includes listings for resources, services, NFTs, and other offerings. Users can follow other users and see their updates.
- A wallet for accessing the user's $GRID$ token balance, transaction history, mutual credit accounts, and NFTs. Users can send/receive payments, take out/repay loans, and manage NFTs.
- A control panel for managing the user's decentralized identity, power fingerprint, personal account, and other profile settings. Users can generate subkeys, disclose data for fingerprinting, set security options, and more.

The workspace provides a simple, cohesive environment for participating in and benefiting from Plurigrid's circular economy. But its modular architecture allows for a diversity of applications, interfaces, and experiences to emerge based on users' needs and interests.

Some potential Plurigrid applications include:

- Microworld generators: Tools for creating/exploring simulated environments, games, VR/AR experiences, and other microworlds. These can be traded as NFTs.
- Decentralized marketplaces: Peer-to-peer platforms for exchanging resources, services, digital goods, and other offerings directly between users.
- Distributed supercomputing: An open marketplace where users can buy/sell computing power for running complex simulations, training machine learning models, rendering graphics, and other compute-intensive tasks.
- Autonomous organizations: Digital organizations with governance and operations managed through smart contracts, voting, and other decentralized mechanisms. They provide a platform for collaboration and collective value generation.

- Digital fabrication: Services for designing and printing 3D objects, electronic components, and other physical goods based on digital files. The printed outputs and designs can be traded in Plurigrid's economy.
- Sharing networks: Platforms that allow people to share access to resources like vehicles, tools, living space, and other physical assets. Excess capacity is distributed where needed, maximizing efficiency and access.
- Decentralized data marketplaces: Peer-to-peer platforms where people can buy/sell access to data, insights, algorithms, and other digital assets. Privacy and security are maintained through Plurigrid's architecture.
- Distributed learning: Open courseware, tutorials, and other educational resources and experiences generated through peer collaboration and available as a shared public good. Knowledge circulates freely.

Plurigrid's open, modular architecture allows applications to emerge, evolve, and interoperate in a decentralized manner. By facilitating circulation and exchange at a resource level, Plurigrid provides the infrastructure for a diversity of marketplaces, tools, organizations, and experiences to flourish in a way that maximizes value and access for all of humanity.

7 Multi-Agent Interactions and Capabilities

In Plurigrid, users can deploy software agents to automate resource usage, transactions, and other activity. Agents negotiate with each other to coordinate resource allocation and maximize outcomes across scales. This enables:

- Efficiency: By optimizing resource usage in a decentralized manner based on real-time conditions and needs.
- Scalability: By distributing governance and control through localized agent interactions. Global outcomes emerge.
- Fault tolerance: By providing redundancy and resilience through a diversity of agents and negotiation pathways.
- Customization: By allowing users to develop agents tailored to their needs, priorities, and values.

Agents interact by exchanging messages and capabilities, with:

- Messages: Representing requests, offers, acknowledgments, and other communications between agents.
- Capabilities: Granting agents authorization to access certain resources or perform specific actions. Capabilities are unforgeable and can be delegated between agents.

Capabilities allow agents to negotiate access to resources in a secure, auditable manner. They are scoped to limit agents to only the level of access needed to fulfill their functions. Capabilities can be revoked at any time.

Some examples of how multi-agent interactions and capabilities enable decentralized governance and control in Plurigrid include:

- Energy distribution: Smart grid agents negotiate how to route excess energy from producers to consumers based on real-time supply/demand and grid conditions. They exchange capabilities to access energy resources and infrastructure.
- Transportation coordination: Agents representing vehicles, traffic infrastructure, and transportation needs negotiate how to efficiently route vehicles and maximize passenger/cargo throughput. They exchange capabilities to reserve road space, parking, charging, etc.
- Supply chain management: Agents representing manufacturers, shippers, warehouses, retailers, and customers coordinate how to optimize the production, distribution, and delivery of goods. They exchange capabilities to access inventory, shipping capacity, and other assets.
- Smart contracting: Agents representing the parties to a contract negotiate terms, monitor compliance, and take action based on events. They hold and exchange capabilities that authorize them to access funds, resources, and systems necessary to execute the contract.
- Data privacy: Personal data agents negotiate how to share private data with other agents/applications based on a user's preferences. They exchange zero-knowledge proofs and other privacy-preserving capabilities to enable selective data disclosure.

Multi-agent interactions provide a mechanism for balancing individual agency with global coordination in a scalable, decentralized manner. Capabilities ensure that agents only gain access to resources and take actions that they are specifically authorized for based on their functions. Together, they enable Plurigrid to operate as an open, self-regulating system.

8 Asynchronous Computing and Meta-Programming

Plurigrid utilizes asynchronous computing where processes execute independently and communicate by exchanging messages. This is in contrast to synchronous computing where processes wait for responses from each other before continuing execution.

Asynchronous computing provides several benefits for a globally distributed system like Plurigrid:

- Parallelism: By allowing processes to execute concurrently without blocking each other, more work can be done in parallel. This maximizes the utilization of distributed resources.
- Responsiveness: Processes do not have to wait idly for responses from other processes that may be delayed. They can continue operating and responding to other requests. This results in a more responsive system.
- Loose coupling: Processes are less tightly coupled since they do not directly depend on immediate responses from each other. This makes the overall system more fault tolerant and flexible. If one process goes down, it does not directly impact others.
- Scalability: The asynchronous model is more scalable since processes do not have to maintain open connections to large numbers of other processes. They simply pass messages without waiting for direct responses. This reduces overhead and allows the system to scale to a global size.

Plurigrid also utilizes meta-programming, where programs operate on and generate other programs as data. This allows Plurigrid to:

- Adapt dynamically: By generating/modifying new programs and code in response to events, Plurigrid can adapt its own behavior and functionality over time without human intervention. This enables continual optimization and resilience.
- Support microworld generation: Users can generate/explore simulated environments, games, VR/AR experiences, and other microworlds by developing programs that operate on and generate new code/content. These microworlds can then be traded within Plurigrid's economy.
- Enable smart contracts: Smart contracts are programs that execute automatically based on events to facilitate coordination and exchange between users. They operate on and modify other programs/systems.
- Facilitate composability: Simple programs can be composed into more complex ones, enabling sophisticated applications and value generation. New programs emerge from the combination and recombination of existing ones.

Together, asynchronous computing and meta-programming provide the mechanisms for Plurigrid to operate as an open, adaptive system that facilitates the perpetual generation of new value and microworlds through composition and recombination. They enable Plurigrid to modify its own behavior dynamically in response to events and user activity. This results in a system that is continually optimizing itself to better serve human needs and interests.

9 Local-First Computing and Interoperability

While Plurigrid represents a globally unified computing system, it adopts a "local-first" approach where resources and capabilities are bound to individual devices by default. This provides:

- Direct ownership and control: Users have a sense of ownership and agency over the resources/capabilities associated with their personal devices.
- Privacy and security: Sensitive data and activity are kept local by default, only accessing global resources when necessary. This minimizes exposure.
- Resilience: Users can continue operating locally even when disconnected from global networks. Local-first functionality is not dependent on always-on connectivity.
- Low latency: Processes can execute locally with minimal latency since they do not have to access remote resources or wait for network responses. This results in a highly responsive experience.

However, local resources and capabilities can be gradually shared or migrated to global namespaces as needed to enable:

- Coordination: Where local systems link up into more complex global systems, facilitating large-scale automation, optimization, and governance.
- Sharing: Where excess local capacity is distributed to where it is most needed, maximizing efficiency and access.
- Continuity: Where data, resources, and capabilities remain accessible

Plurigrid achieves interoperability between diverse local systems and global resources through:

- Standardized interfaces: Plurigrid specifies standardized interfaces for accessing distributed resources and services. Local systems implement these interfaces, enabling interconnection.
- Loose coupling: Plurigrid employs a loosely coupled architecture where local systems can operate independently but link up into more complex global systems when needed. They are not tightly dependent on each other.
- Asynchronous messaging: Local systems communicate by passing messages asynchronously without having to wait for direct responses. This allows them to interoperate without maintaining constant open connections.
- Capability-based access: Local systems gain access to global resources by presenting unforgeable capabilities. These capabilities authorize access to specific resources/services without requiring universal connectivity.

- Selective disclosure: Local systems choose which data, resources, and capabilities to disclose at a global scale based on privacy preferences and needs. They can keep sensitive resources local while still benefiting from global interconnection.

Some examples of how Plurigrid enables interoperability between local systems and global resources include:

- Personal data: Individuals can choose to keep personal data locally on their devices by default but selectively disclose certain data to global applications/services based on needs and privacy preferences. Capabilities authorize disclosure.
- Smart homes: Home automation systems operate locally but link up into global smart grid networks when excess energy capacity is available for distribution or resources are needed. They interoperate through standardized energy trading interfaces and capabilities.
- Transportation: Vehicles operate locally but coordinate at a global scale with traffic infrastructure, ride-sharing platforms, and smart cities when needed. They interoperate through mobility protocols and the exchange of capabilities to access road networks, parking, etc.
- Manufacturing: Local factory equipment and robots operate autonomously but coordinate with global supply chain networks for just-in-time production and delivery of parts/materials. They interoperate through manufacturing and logistics protocols.
- Healthcare: Personal health devices operate locally but share certain data with healthcare providers, research institutions, and public health networks globally based on privacy preferences. They interoperate through health data standards and selective data disclosure.

By combining local-first computing with interoperability through standardized interfaces, loose coupling, asynchronous messaging, capability-based access, and selective disclosure, Plurigrid facilitates a globally unified system where local resources are bound to users by default but can be gradually shared and linked up into more complex global systems as needed. This balances individual ownership and control with large-scale coordination, optimization, and value generation.

10 Business Models and Value Creation

While Plurigrid aims to provide an open infrastructure that benefits humanity as a whole, private companies can still build successful business models by:

- Developing Plurigrid-compatible devices and hardware: Including smart meters, IoT sensors, 3D printers, networking equipment, and other infrastructure. These provide an interface to Plurigrid's global services.

- Building applications and tools: Including microworld generators, decentralized marketplaces, distributed supercomputing services, digital fabrication platforms, autonomous organization management systems, and other applications. These leverage Plurigrid's infrastructure.
- Providing managed services: Including data storage, computing, hosting for decentralized applications, indexing/search, AI, and other managed services. These operate on top of Plurigrid's distributed architecture.
- Developing templates and solutions: Including smart contracts, data licensing agreements, crowdfunding frameworks, and other templates that users can build upon. These facilitate new interactions and value generation within Plurigrid's network.
- Offering consulting and support: Helping individuals, communities, and enterprises benefit from and contribute to Plurigrid's circular economy. This includes services around sustainability, decentralization, tokenomics, and other relevant areas.
- Generating and selling NFTs: Developing and selling NFTs that provide ownership and access rights to resources, digital goods, services, experiences, and other offerings within Plurigrid's network.
- Providing localized infrastructure: Deploying infrastructure for smart cities, smart buildings, smart homes, smart factories, and other environments. This infrastructure integrates with Plurigrid to enable local-first computing combined with global interconnection.

These business models create value by building tools, applications, services, and infrastructure compatible with Plurigrid's open technology stack. They provide an interface to Plurigrid's global functionality while still operating as independent businesses. Revenue comes from sales of products/services, NFTs, subscriptions, consulting fees, and other sources.

By facilitating an open, decentralized infrastructure, Plurigrid unlocks new opportunities for value creation that benefits both private businesses and the public. This shared value model encourages companies to build products and services that maximize access, sustainability, and human flourishing rather than extraction and concentration of wealth. Together with open-source communities and public institutions, private businesses can help realize Plurigrid's vision of a circular economy that unlocks creative potential at a global scale.

11 Conclusion

In summary, Plurigrid concepts provide a blueprint for globally unified computing that balances individual agency and emergence with scalable segmentation, access management, and global optimization.

A gradual, open approach builds initial Plurigrid services for high-coordination use cases, enabling modular integration and focusing on shared functions. It proceeds iteratively, adapting to feedback. An individual-first strategy develops affordable, open tools that distribute capability and maximize Plurigrid's ability to empower all individuals.

To realize this vision, we must demonstrate concepts, build minimum viable infrastructure and accumulate enough compute/value to prove the circular economic model. By democratizing access, fostering grassroots collaboration, and balancing individual/global needs, Plurigrid can transition us to a sustainable circular economy at a global scale.

The time for globally unified computing that unlocks creative potential in all of humanity is now. Together, we can build a future of perpetual progress, shared ownership, and open cooperation that benefits humanity as a whole. Let us begin.