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## Introduction

### Gridcoin

Gridcoin is an open-source blockchain that mints and distributes cryptocurrency in relation to the processing power a network participant directs toward data-driven analysis and scientific discovery. The Gridcoin blockchain is secured through a proof-of-stake protocol and monitors processing contributions to the Berkeley Open Infrastructure for Networked Computing. Access to Gridcoin's computation resources is free for any project with data to process, while participants of the Gridcoin network are incentivized with cryptocurrency minted by the Gridcoin protocol.

### The Berkeley Open Infrastructure for Network Computing (BOINC)

The Berkeley Open Infrastructure for Network Computing (BOINC) is an open-source grid computing infrastructure which provides open access to a global volunteer-based distributed computing network. To date, BOINC has been the driving force behind numerous computationally intensive research programs, such as pulsar identification, the creation of patient specific cancer treatments, the simulation of candidate molecules for next-generation solar panels, along with many others. While BOINC has been used primarily for science and mathematics, it can host data from any open or commercial field so long as the data can be formatted for BOINC's processes. Examples of projects include tasks on engineering, cryptography, rendering, weather and climate prediction, as well as social, market, and resource

analytics. Enigma@home, for example, worked to break remaining WWII messages encrypted by an Enigma machine.

## Computation Power

As of July 2019, BOINC hosts about 24 petaFLOPS of processing power. For comparison, the top-ranked supercomputer in June 2019, IBM's Summit, hosts 143 petaFLOPS. IBM's Sierra, ranked second, hosts 94 petaFLOPS. The Sunway TaihuLight hosts 93, the Tianhe-2 hosts 61, and Dell's Frontera hosts about 23.5 petaFLOPS.

This establishes BOINC as the world's fourth largest supercomputer by FLOPS

Gridcoin contributes 4.5 petaFLOPS of processing power to BOINC, making up 18.8% of BOINC's processing power.

## Results

More than 165 scientific papers have been published using results from BOINC projects.

# The Gridcoin Network and Protocol Overview

Gridcoin is the world's largest BOINC team and the only permissionless blockchain and cryptocurrency designed and maintained under an open-source operation model by long-standing BOINC participants. The Gridcoin network, its protocol, and its processes use distributed ledger technology and other resources to incentivize, democratize, advance, and educate the public on distributed computing and science. Gridcoin utilizes distributed ledger and democratized incentive technology to significantly increase the computation potential of the BOINC network. To achieve this, the Gridcoin distributed ledger implementation incorporates records of participant computation contributions to BOINC projects elected for inclusion by members of the Gridcoin network ([pg. 7](#)). A significant portion of the currency minted by the Gridcoin protocol is directly distributed to these participants based on their relative computation contributions. Additionally, the Gridcoin currency minting mechanism incentivizes participants to evenly distribute their crunching power across the included BOINC projects ([pg. 13](#)).

Gridcoin - Blockchain, Economic Protocol, and Incentivization Layer		
Distributed Computing Platform - BOINC		
Participant Computer	Participant Mobile	Participant Server

# The Gridcoin Network

## Organization, processes, and decision making

Conservatively estimated, there are 13,500 active network participant's incentivized by Gridcoin as of June 17th, 2019. According to statistics collected from BOINCStats<sup>1</sup>, the Gridcoin network offers between 5 and 8 total PFLOPs across all Gridcoin whitelisted BOINC projects.

Gridcoin FLOP contribution is calculated based on the sum of the network's percent RAC contribution to each project multiplied by the FLOPs presented on each project's server status page.

## Organization

Gridcoin operates under a blockchain-based open-source operation and governance model. There are no owners, proprietors, executives, board of directors, or other assigned titles. Necessary responsibilities are entrusted to reputable contributors of the project. Gridcoin can be utilized and supported by LLCs, non-profits, and other organizational entities, but is itself a permissionless blockchain network.

## Participants

There are four technical participants in the Gridcoin network.

### Crunchers

Crunchers are nodes with registered beacons. They contribute computation power to whitelisted BOINC projects.

### Stakers

Stakers are nodes actively securing the Gridcoin blockchain. They maintain an active balance in an attempt to be chosen as a block producer.

Stakers are additionally responsible for forming consensus on statistics published by Oracles along with executing the superblock algorithm that calculates and publishes each participant's earned research rewards.

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<sup>1</sup>real-time stats at <https://boincstats.com/en/stats/-1/team/detail/118094994/overview>

## Statistics Providers

Statistics providers are third party entities that record participant statistics for collection by Gridcoin oracles. In the current network, these are whitelisted BOINC projects.

## Oracles

Oracles are verified nodes that collect, hash, sign, and publish participant contribution statistics from statistic providers.

## Currency

A necessity of a permissionless blockchain is a currency which incentivizes participation in securing the integrity of the ledger and its recorded transactions. GRC is the currency of the Gridcoin blockchain.

## Protocol

The Gridcoin protocol is a permissionless, trustless, and transparent economic system defined and enforced by open-source code run by a set of network nodes. It evolves through node consensus around the system code.

## Economics

Gridcoin's GRC has evolved through several protocol shifts. Below are the current economic rules of the system.

### **Total Supply as of July 1st 2019**

420,000,000 GRC

### **Total Minted per Year**

13,724,000 GRC

### **Distributed to Crunchers per Year**

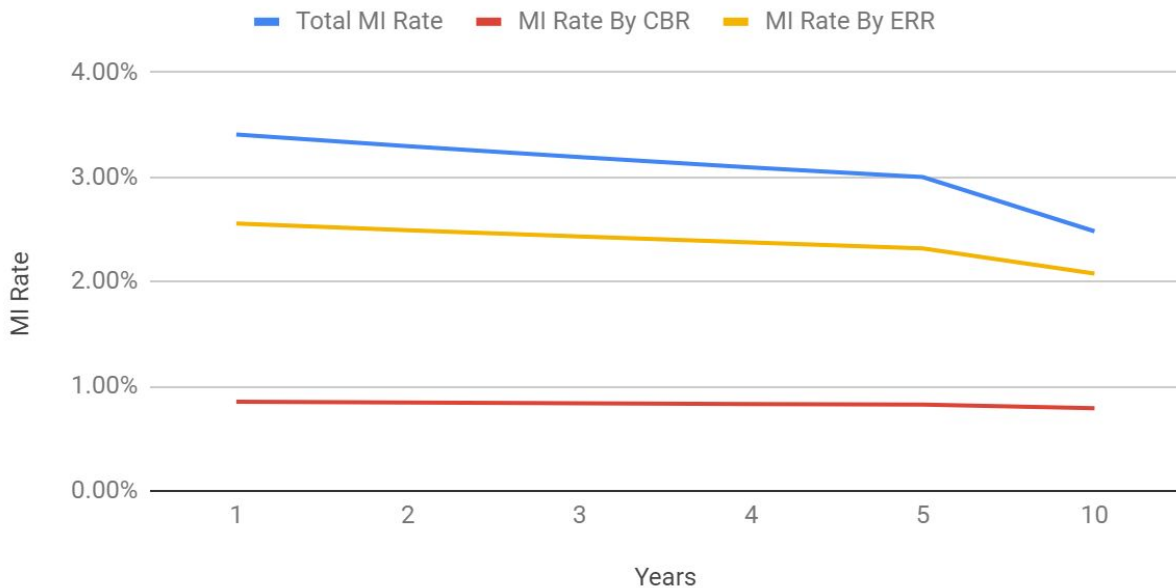
10,293,000 GRC

### **Distributed to Stakers per Year**

3,431,000 GRC

# Monetary Inflation Rate

After Implementation of CBR



## The Gridcoin Foundation

The Gridcoin Foundation is a community-managed wallet of ~30 million GRC. The Gridcoin Foundation's expressed purpose is to support the development of the Gridcoin protocol and growth of the Gridcoin network.

The GRC of The Gridcoin Foundation is held in a non-staking, multi-signature wallet. The keys to this wallet are held by a group of long-standing, reputable, verified, and trusted individuals. The wallet requires approval from a majority of key holders to enable any transfer of GRC out of the foundation wallet, and this behavior is enforced on a technical level.

## Voting

Changes to the functionality and structure of the Gridcoin network are implemented by software alterations by Gridcoin developers that are committed to a public repository. By installing or refusing to install upgraded software incorporating these changes, network participants ultimately exercise final decision-making authority.

To facilitate unified decision making among nodes, the Gridcoin network utilizes an open and transparent blockchain-based polling mechanism accessible through the wallet software GUI. Polls serve to inform participants on decisions, to give developers direction on where the

network wants to go, and to seek common ground or otherwise mediate arguments on network protocol and operation.

For example, if a developer wants to write a protocol improvement which might split the network into one part that supports the development and one that does not, a poll with both pros and cons is drawn up and presented to the network. The result of the poll will tell the developer whether the network supports or rejects the idea, which in turn encourages or discourages the initiative.

Additionally, if a contributor wants to seek foundation reimbursement for their work, they can create a poll with a proposal or reimbursement request.

Another direct role the polling process serves is to manage Gridcoin's list of BOINC projects approved for inclusion in Gridcoin's record of BOINC project contributions, which is fundamental to Gridcoin's research computation contribution structure ([pg. 7](#)).

There are currently 7 types of polls. Each poll type has unique requirements and validation parameters formulated from prior poll experiences and bootstrapped by prior network polls. The poll types are:

1. Opinion/Casual
2. Development
3. Marketing
4. Outreach
5. Management
6. Community
7. Whitelist

These categorizations assist in defining the issue at hand and increase the likelihood of a poll reaching a clear and definitive result. Details on the specific types of polls are beyond the scope of this document and should be viewed on GitHub at the following link:

<https://github.com/gridcoin-community/Gridcoin-Tasks/issues/227>

## The Gridcoin Whitelist

The Gridcoin Whitelist is a fundamental structure and sub-ledger of the Gridcoin blockchain. Technically, this is a curated, network-elected list of URLs for BOINC project statistics which are periodically polled to request updated figures of contributor Recent Average Credit [RAC].

To qualify for inclusion in the Gridcoin network's "whitelist" of BOINC projects whose participants are rewarded relative to their RAC contributions, a project must satisfy a number of criteria.

These criteria are designed to ensure that the projects are legitimate scientific projects offering a fair chance for all participants to receive work and credit, and that they are not pseudo-projects designed specifically to manipulate or damage the Gridcoin network by reporting false or unvalidated RAC figures.

## Technical Requirements

A summary of the whitelisting requirements are as follows. To qualify for inclusion, projects must:

- **Validate work units** and detect possible cheating or hardware malfunctions.
- **Consistently generate work units** at a level that handles the computation power offered by the Gridcoin network.
- **Fairly** distribute work units to all viable crunchers
- **Produce statistics information daily** at the user, team, and (preferably) host level.
- **Employ reasonable standards** for reliability and availability of the project resources, such as project website, forums, and contact information.

A full list of technical requirements can be found on GitHub at the following link:

<https://github.com/gridcoin-community/Gridcoin-Tasks/issues/227>

## Economic Rationale

Emerging digital technologies such as blockchain offer the chance to reimagine how participants in a society can shape its development through allocation of resources. Gridcoin emission level distribution of GRC is a key aspect of a new type of economic system that more directly represents the will of all network participants. To achieve this, Gridcoin uses a blockchain-based poll to encourage all participants to decide the whitelist status of any BOINC project, thereby ultimately choosing where GRC is allocated and incentivizing the application of computing power to a curated set of projects as a result.

If a BOINC project is approved and added to the Gridcoin whitelist, any subsequent cruncher of that project has the option to be rewarded with GRC, regardless of whether the cruncher was part of the network or participated in voting at the time of approval. This incentivizes current and new crunchers to apply their power to whitelisted projects, increasing the overall resources available to these projects.

The whitelist process also adds two incentivized education layers to the system.

1. The democratic nature of the whitelisting process incentivizes BOINC projects to educate network participants on the details and value of their research to increase the



chances of network participants voting in favor of inclusion of the project to the Gridcoin network.

2. The whitelisting process combined with cryptoeconomic principles incentivizes network participants to remain literate and aware of the research, capabilities, and execution of BOINC projects or seeking a place on the Gridcoin whitelist, helping to ensure that project research quality remains high and results are not faked.

These incentives are detailed in the section titled *process-based incentives* ([pg. 13](#)).

## Share of Network Computation Power

Gridcoin's current system produces an expected  $1/n$  percentage of the network's computation power directed to each whitelisted project, where  $n$  is equal to the number of whitelisted projects.

This structure is detailed in the section titled *process-based incentives* ([pg. 13](#)).

## Project Management (Whitelist/Greylist)

A project is automatically removed from the Gridcoin whitelist if it can no longer comply with a critical requirement, such as disallowing new user sign-ups. A project can also be removed from the whitelist through a network poll.

A network poll is required to re-whitelist a project once it is removed.

The Gridcoin greylist is an additional sub-ledger of the Gridcoin network. It serves as an intermediary ledger for projects which might temporarily fail a non-critical technical requirement of the whitelist. When such a failure occurs, the project is removed from the whitelist and placed on the greylist. If the failure is remedied within the greylist protocol's allotted time the project is removed from the greylist and placed back on the whitelist.

For example, a project will be moved to the greylist if it halts work unit distribution. It will be moved back to the whitelist if it resumes work unit distribution within the time allotted by the rules of the greylist protocol. If it does not resume work unit distribution in the allotted time it will be removed from both the greylist and the whitelist.

GRC is not distributed to participants contributing to projects on the greylist.

The greylist helps ensure fair distribution of GRC to participants actively contributing computation to approved projects. It also serves to lessen the need for de-whitelisting polls for technical reasons. This focuses whitelist removal polls on the management and merits of the project in question.

# The Gridcoin Blockchain and Protocol

## Blockchain Consensus

Gridcoin utilizes a proof-of-stake algorithm to secure and progress its blockchain. PoS consensus frees participant computing power for contributions to BOINC projects while ensuring a secure ledger and avoiding the consumption of staggeringly large amounts of electricity to maintain that security.

A detailed overview of the Gridcoin PoS consensus protocol can be found at the link below.

[https://drive.google.com/file/d/1NwEBSKuG2lvZXPvzbTEvZLpaN2JCP\\_nK/view](https://drive.google.com/file/d/1NwEBSKuG2lvZXPvzbTEvZLpaN2JCP_nK/view)

## The Gridcoin Oracle and Superblocks

The Gridcoin network must collect user computation statistics from BOINC project servers in order to accurately distribute GRC based on participant computation contributions. The protocol does this automatically, roughly once per day. At the end of each collection, the network agrees on the RAC statistics for all active Gridcoin participants. These statistics are recorded on the Gridcoin blockchain in unique blocks called superblocks. The recorded information is comprised of project names, network average and total RAC contributions, and user CPIDs with their associated magnitude. No private user information is recorded as a part of this process.

## The Gridcoin Oracle

Gridcoin implements a unique, decentralized, inbound oracle mechanism and consensus algorithm. The Gridcoin oracle determines network participant crunching contributions and calculates their earned research rewards. The implementation of this oracle currently serves three additional purposes:

1. To maintain low connection loads to BOINC project servers
2. To scale the statistics collection and processing mechanism to tens of thousands crunchers
3. To enable collection of statistics from GDPR-compliant BOINC projects

## Process Overview

### **Superblocks**

1. **A superblock contains** the officially sanctioned network statistics encoded in the blockchain.
2. **A superblock is due** 24 hours after the previous one is staked.
3. **Statistic consensus and superblock staking can take** from a few minutes after the process begins to two hours after the superblock is due.
4. **Oracle nodes and the network retain 48 hours** of filtered statistics from the oracles for cross-checking by the nodes to ensure no corruption by an oracle node occurred.
5. **Oracle nodes can use username/password authentication** for access to the statistics site if the statistics are not publicly accessible. In these cases, statistics are only collected from users who have given permission to allow their statistics to be used for this purpose.

### **Oracle Node and Project Server**

1. **Six Oracle nodes connect** to each project server 4 hours before a superblock is due.
2. **Gridcoin team statistics files** are downloaded once and the information is cached.
3. **Consensus on statistics** is attempted.
4. **Superblock staking** is attempted.
5. **The user statistics file is monitored** during this process and changes to the statistics files are downloaded until the superblock is staked.

A full write-up on this process can be found at the link below.

<https://docs.google.com/document/d/1SQEGDPGqnb9as9XUraoLqNn7uTQsrbmHqEXwFaxiGE/edit?usp=sharing>

## **Beacons**

A Gridcoin beacon ties a Gridcoin address' public key with a BOINC CPID. Beacons are necessary to track a participant's magnitude and release the appropriate earned research rewards to the corresponding participant.

## Magnitude

Magnitude is a Gridcoin-specific statistic defined for each beacon. It is derived through a calculation involving a participant's computation contribution to a project relative to other participants contributing to that same project, the total number of whitelisted projects, and a targeting magnitude-unit. The targeting magnitude-unit is a protocol tool used to control the emission rate of GRC.

## Research Savings Accounts (RSA)

A participant's earned research rewards are calculated and tied to a beacon with each superblock. The amount of GRC owed to a beacon is stored in that participant's research savings account (RSA). The RSA tracks the research rewards owed to a beacon for as long as that beacon remains active.

## Distributing Participant Earned Research Rewards (ERR)

Distributing a participant's earned research rewards is a resource-intensive task comparable to sending a transaction across the blockchain. The protocol currently handles this task by releasing a participant's ERR to their beacon's associated address when that address stakes a block.

## Side-Staking

*Concept and initial implementation credit: PINK and the Pinkcoin community.*

Side-staking enables automated percentage-based splitting and transfer of earned staking and research rewards. This mechanism offers security to major GRC network security stakeholders while enabling automated funding of development, initiatives, entities, and businesses, and automated donation to external entities accepting GRC.

Gridcoin adopted and implemented a unique side-staking mechanism based on the concept first implemented by PINK.

<https://github.com/gridcoin-community/Gridcoin-Research/pull/1265>

## Gridcoin Incentives

Gridcoin is a multi-incentive blockchain uniquely capable of incentivizing any leaderboard-style ledger at an emissions level. The network's current and foreseeable incentive focus is on data analysis, science and scientific contributions, research, scientific inclusion, and education.

## Protocol-based Incentives

The Gridcoin blockchain protocol mints a cryptographically secured cryptocurrency, GRC, and distributes it to participants that perform two tasks:

1. The task of ledger security and progression.
2. The task of contributing computation cycles to whitelisted BOINC projects.

Emissions level distribution of GRC to participants contributing to these tasks drives block creation and incentivizes computation contributions to data analytic research projects.

## Process-based Incentives

Gridcoin contains several processes that incentivize distributions of resources, education, participation, and expansion of science literacy.

### Crunching Contribution Distribution

In order to give fair treatment to all whitelisted projects, each whitelisted BOINC project is assigned an equal portion of total network magnitude. The share of generated GRC corresponding to a project's assigned magnitude is then distributed to its participants based on each participant's computation contribution relative to the project's remaining participants.

This distribution structure monetarily incentivizes a significant portion of network participants to distribute their computation contributions across projects or to projects that would otherwise lack contributors in order to achieve the highest magnitude on an individual basis. The end result is a fairly even distribution of Gridcoin's computation power across whitelisted projects regardless of a project's relative value or marketing abilities.

### Active Education Through the Gridcoin Whitelist Process

As detailed above, the Gridcoin network offers a significant total amount of computation power. A BOINC project must be whitelisted in order to access a share of this computation power. A project is whitelisted through a network poll. A project is more likely to be whitelisted if it can clearly communicate its research, operation, and value to the network at large.

This encourages BOINC projects to develop communication tools and materials that are useful and informative to the general population of the Gridcoin network and not solely for publication.

### Passive Education Through the Gridcoin Whitelist Process

The Gridcoin whitelist is a sub-ledger of projects approved by network participants. Each project represents the values of the Gridcoin network at large. Each project on the whitelist adds or

detracts value to or from the sub-ledger based on the project's perceived social impact or contribution to science and its foundations.

As a result, Gridcoin network participants are incentivized to remain literate and aware of the research, capabilities, and execution of BOINC projects on or seeking a place on the Gridcoin whitelist. These participants play an active role in helping to ensure that included projects are conducting high-quality research and have a strong incentive to detect hacking or fraud that might affect their individual rewards.

## Passive Education Through Blockchain Principles

Democratizing access to a currency at an emission level incentivizes people to participate in the system. In addition, a participant with an active stake in a system is more likely to pay attention to that system. In doing so, the participant will learn more about the driving forces of the system.

Democratized systems based on financial technology, such as DLT systems, educate their participants on money and monetary policy, protocol, and process.

A democratized system based on financial technology and science, such as Gridcoin, educates its participants on the policies, protocols, and processes of both money and science.

# Gridcoin Values

Gridcoin is an open-source organization with no central decision making authority. While flexibility is required in relationships and partnerships, these base principles must drive ultimate mediation of direction when all other avenues of merit based discussion fail.

## Open Source

Gridcoin software is hosted on GitHub under the MIT license. Anyone may access, view, modify, learn from, experiment with, or copy the software. Gridcoin's commitment to open-source software brings several benefits. Since anyone familiar with the programming language (currently C++) may contribute, the software is easily extended, audited, and maintained. This inherent flexibility of open-source means that Gridcoin development can quickly respond to challenges as they arise. Open-source empowers programmers and contributors to recognize issues in the code before they present in production.

## Open Data

The data on the blockchain is accessible either through the wallet software or through web-based blockchain explorers. As a global open-ledger system, blockchain technology keeps the data both open and secure.

Gridcoin supports the open publishing of data which in turn allows more people to analyze and otherwise experiment with the data.

## Open Access

Access to the Gridcoin network and its services is systematically unrestricted. Network consensus is the only barrier to access of the network's computing services. This permits nearly instant, entirely borderless, censorship resistant transactions between parties.

Gridcoin supports open access to academic publications, as this encourages public engagement with science and open data, consistent with Gridcoin's ideals.

## Open Education

The aforementioned open-knowledge principals culminate in open-education. Being an open-source community means that Gridcoin supports the development of Open Education Resources.

A more educated society means a more educated network and more educated contributors from all relevant fields. The current approved distributed-computing platform, BOINC, enables not only massive laboratories, organizations, or research universities to produce projects for discovery, but individuals as well. Gridcoin values this type of open education initiative and whitelists projects of all size and scope.

## Decentralized Operation

'A decentralized system is where some decisions by the agents are made without centralized control or processing. An important property of agent systems is the degree of connectivity or connectedness between the agents.'

- Norman L. Johnson

Decentralization solves the single point of failure problem, allows for diversity, larger participation in decision-making, provides equality, and limits encroachment by centralized authorities

# Additional Resources

### **Website and Wallet Software**

Website and Wallets

<https://gridcoin.us>

## **Development Repositories**

Gridcoin Research Client

<http://github.com/gridcoin-community/Gridcoin-Research/>

Gridcoin Research Community - For non-wallet based projects

<https://github.com/gridcoin-community>

## **Block Explorers**

Gridcoinexplorer

<https://grcexplorer.neuralminer.io>

Gridcoin.Network

<https://gridcoin.network>

Gridcoinstats

<https://www.gridcoinstats.eu/>

## **Social Media**

Twitter

<https://twitter.com/GridcoinNetwork>

Reddit

<https://reddit.com/r/gridcoin>

Discord

<https://discord.gg/jf9XX4a>

Slack

[https://join.slack.com/t/teamgridcoin/shared\\_invite/enQtMjk2NTI4MzAwMzg0LTUzMmY0YjdiNzYxYzQ0Mdc3MGE1NjQ3Nzg2NWMzZTUzMjAwZjdhMWI1YWUzMDE4YzQyZjVjMjMzOTc1M2RmMmM](https://join.slack.com/t/teamgridcoin/shared_invite/enQtMjk2NTI4MzAwMzg0LTUzMmY0YjdiNzYxYzQ0Mdc3MGE1NjQ3Nzg2NWMzZTUzMjAwZjdhMWI1YWUzMDE4YzQyZjVjMjMzOTc1M2RmMmM)

Medium

<https://medium.com/@gridcoinnetwork>

Steemit

<https://steemit.com/created/gridcoin>

Facebook

<https://www.facebook.com/gridcoins>

Telegram



<https://t.me/gridcoin>