GRIDCOIN WHITE PAPER

THE COMPUTATION POWER OF A BLOCKCHAIN DRIVING SCIENCE & DATA ANALYSIS

VERSION 1.0.0

Gridcoin

Table of Contents

How much Idle Processing Potential is there?

An iPhone 6 is capable of running 7 gigaFLOPS.

If we assume all 2.5 billion smartphones in circulation operate at this level, smartphones form a network of about 17.5 exaFLOPS.

If these smartphones are idle half of the time, we can say the IPP of the global smartphone computing network is about 8.75 exaFLOPS.

There are expected to be over 5 billion smartphones in global circulation by 2020.

Utilizing IPP

Did you know that certain data analytic tasks work better on CPUs over GPUs? It is even possible to build tasks to work most efficiently on dated hardware.

Mission

Gridcoin is a blockchain-based distributed computing network powered by the idle processing potential of existing hardware. Access to this network is free for those with data to process, while participants of the network are incentivized with cryptocurrency minted by the Gridcoin protocol.

Overview

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. Currently, the Gridcoin blockchain is secured through a proof-of-stake protocol and monitors processing contributions to the distributed computing infrastructure, BOINC.[1] BOINC, the Berkeley Open Infrastructure for Network Computing, hosts major institutional computing projects such as IBM's World Community Grid,[2] SETI,[3] and data from the Large Hadron Collider,[4] alongside projects developed by students, enthusiasts, mathematicians, researchers, and citizen scientists.

Idle Processing Potential

Gridcoin defines Idle Processing Potential (IPP) as the processing power of a computing device multiplied by the proportion of unused processing over time. Any object that houses a processor is potentially part of this network. This includes not only computers, but also everyday objects such as phones, gaming systems, cars, toys, and smart appliances. IPP represents an enormous resource which will continue to grow as processors and embedded devices become an increasingly pervasive part of modern life. Gridcoin taps into this significant potential from both legacy and developing systems by encouraging the contribution of IPP to approved distributed computing platforms.

---

1   https://boinc.berkeley.edu
2   https://worldcommunitygrid.org
3   https://setiathome.berkeley.edu
4   http://lhcathome.web.cern.ch/

Gridcoin

BOINC Projects

GRC can only be minted for crunching projects that are on the *Gridcoin whitelist.*[13] Whitelisted projects are italicized below, list accurate as of 3 March 2018.

Biology & Medicine:
- DrugDiscovery@Home
- » *GPUGrid.net*
- RNA World
- » *Rosetta@home*
- » *TN-Grid*

Cognitive Science & AI:
- MindModeling@home

Distributed Sensing:
- Quake Catcher Network
- Radioactive@Home

Earth Science:
- Climateprediction.net

Physical Science:
- Acoustics@home
- » *Asteroids@home*
- » *Cosmology@Home*
- » *Einstein@home*
- Leiden Classical
- » *LHC@home*
- » *Milkyway@home*
- » *SETI@home*
- SourceFinder
- » *theSkyNet POGS*
- Universe@home
- » *VGTU project@Home*

Mathematics:
- » *Amicable Numbers*
- » *Collatz Conjecture*

Math/Computing/Games:
- » *Enigma@Home*
- Gerasim@Home
- Moo! Wrapper
- » *NFS@home*
- » *NumberFields@home*
- ODLK
- » *ODLK1*
- primaboinca
- » *PrimeGrid*
- SAT@home
- » *SRBase*
- » *SZTAKI Desktop Grid*

Multiple Applications:
- CAS@home
- » *Citizen Science Grid*
- » *World Community Grid*
- » *YAFU*
- » *Yoyo@home*

Approved Distributed Computing Platforms

Distributed computing platforms are larger entities approved by the Gridcoin network. They might host multiple data-processing projects while having only some of those projects approved for use by the Gridcoin network.

The Berkeley Open Infrastructure for Network Computing

The Berkeley Open Infrastructure for Network Computing (BOINC) is an open-source distributed computing infrastructure which provides anyone with data the opportunity to process that data for near zero cost by utilizing 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,[5] the creation of patient specific cancer treatments,[6] the simulation of candidate molecules for next-generation solar panels,[7] 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,[8] for example, works to break remaining WWII messages encrypted by an Enigma machine.

Operation

BOINC consists of two main components: a project server system and client software. The project server, hosted individually by each BOINC project, stores and distributes project data to the client software running on volunteers' host computers. Once the host completes the data crunching task, known as a *work unit*, it returns the results to the project server. Upon verification of the validity and honesty of the completed work unit, a reward in the form of BOINC credits is distributed to the host which completed the task. Credits serve primarily as a proof of participation tool in BOINC's larger gamification system. Outside of BOINC, Gridcoin uses a participant's earned BOINC credits to calculate their relative GRC reward.

---

5 https://einsteinathome.org/science/discoveries
6 https://www.worldcommunitygrid.org/about_us/viewNewsArticle.do?articleId=395
7 https://www.worldcommunitygrid.org/about_us/viewNewsArticle.do?articleId=387
8 http://www.enigmaathome.net/

Power

As of January 2018, BOINC hosts about 21 petaFLOPS of processing power.[9] For comparison, the currently top-ranked supercomputer, the Sunway TaihuLight, hosts 93 petaFLOPS. The Tianhe-2 supercomputer, ranked second, hosts about 34 petaFLOPS. The Piz Daint, the third most powerful supercomputer, hosts about 20 petaFLOPS.[10]

28%
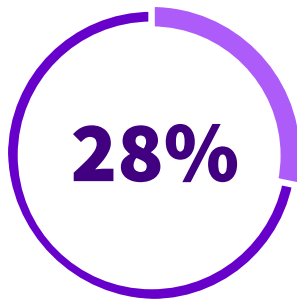
Gridcoin contributes 6.16 petaFLOPS of processing power to BOINC, making up 28% of BOINC's processing power.[11]

Results

At least 165 scientific papers have been published using results from BOINC projects. A list of these papers can be found on the BOINC wiki page.[12]

Future Platforms

Additional data-processing platforms are eligible for inclusion, should they be approved by the Gridcoin network.

Gridcoin

The Gridcoin blockchain genesis block was mined using a proof-of-work protocol on October 16th, 2013. Gridcoin continued as a proof-of-work blockchain until October 11th, 2014, when it forked onto a proof-of-stake protocol which secures the blockchain based on the number of active GRC on the Gridcoin network. Gridcoin has evolved through several iterations of proof-of-stake and incentive structures. Currently, proof-of-stake is used to secure the Gridcoin blockchain while the primary incentive structure is based on processing power contributed to approved BOINC projects.

---

9   https://boincstats.com/en/stats/-5/project/detail
10   https://www.top500.org/lists/2017/11
11   https://boincstats.com/en/stats/-5/team/detail/05d4b63c40a4d8c2b3dd2180f656931f
12   https://boinc.berkeley.edu/wiki/Publications_by_BOINC_projects

Why Proof of Stake?
Proof-of-stake is a green blockchain security protocol developed in 2013. It performs the function of Bitcoin's proof-of-work without the need for energy intensive calculations

This frees GPUs (and CPUs) from the task of securing the blockchain. Gridcoin incentivizes participants to direct these processing resources to the completion of real world analytical tasks.

Security

The Gridcoin blockchain is secured through a proof-of-stake mechanism similar to most other proof-of-stake blockchains. Proof-of-stake is a proven protocol that uses minimal processing resources and rewards stakers of blocks with the transaction fees in those blocks.

Incentive

Gridcoin has developed an additional incentive mechanism called *GRCResearch-Mint*. GRCResearch-Mint operates by minting a protocol-defined number of the GRC cryptocurrency per day and distributing these GRC to participants based on each participant's relative processing contributions to approved data analytics projects. Defined in this way, there is no limit to the number of GRC minted: GRC is a protocol-defined inflationary cryptocurrency.

Approved Data Analytics Projects

Data analytics projects are projects hosted by approved distributed computing platforms or as stand-alone projects.

Data analytics projects are approved through the Gridcoin whitelist processes. The Gridcoin whitelist is a list of projects approved by Gridcoin network participants. The whitelist is managed through a parameter defined process in conjunction with blockchain voting.

BOINC Data Analytics Projects

The BOINC distributed-computing platform hosts dozens of whitelist approved data analytics projects. The actively maintained list can be found on the Gridcoin website.[13]

Stand-Alone and Other Platforms' Data Analytics Projects

Gridcoin is ready to receive proposals. Interested parties can reach the developers by creating an issue at https://github.com/gridcoin-community/Projects/issues. If possible include a brief overview of your project.

---

13   https://www.gridcoin.us/Guides/whitelist.htm

A Blockchain for Everyone

While founded by those closest to blockchain technology, the Gridcoin ecosystem is one of perpetual growth and expanding inclusion. Anyone who sees a path to make the Gridcoin protocol fit their unique needs is encouraged to participate in its continuing development, from coding, to writing, to the contribution of ideas.

Participants

Gridcoin participants are individuals or entities who are active in the Gridcoin ecosystem. There are currently two types of participants.

Crunchers

Crunchers are participants who contribute their IPP to approved data analytics projects. Their participation ensures the continued analysis of data approved by the Gridcoin network.

CRUNCHER

Results

Work

GRC

PROJECT SERVER

Cruncher Contribution Data
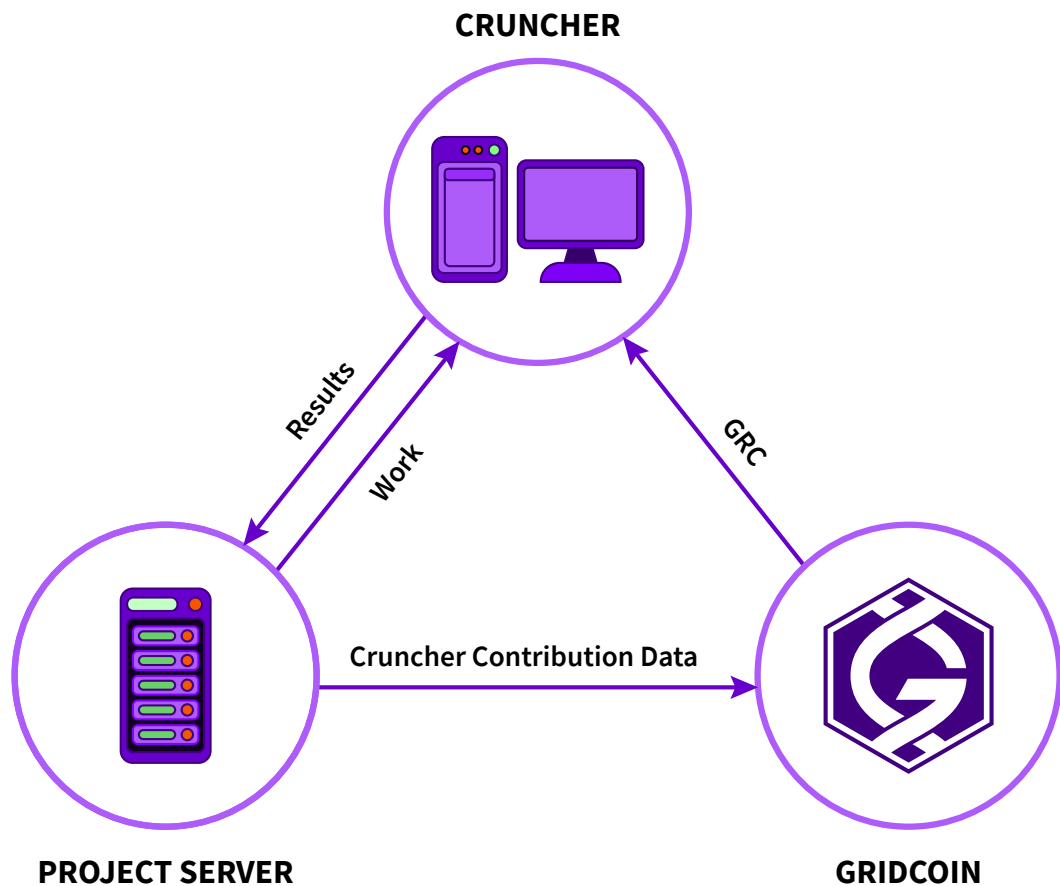
GRIDCOIN

Stakers

Stakers are individuals who secure and advance the Gridcoin blockchain through the proof-of-stake protocol by maintaining an online wallet with a GRC balance. Their participation ensures the decentralized creation of blocks and superblocks while protecting the blockchain from adversaries.

Fetching Participant IPP Contribution Statistics

In order to accurately aggregate a participant's contribution statistics for storage on the blockchain, Gridcoin developed a tool known as a superblock. Superblock data is translated into the Gridcoin variable known as magnitude, a quantifier representing a participant's contribution to a project. Magnitude then determines how much of the protocol-defined GRCResearch-Mint each participant receives. Each data analysis platform is given its own superblock with a unique magnitude formula.

BOINC Superblocks

BOINC superblocks fetch a participant's BOINC recent average credit, also called researcher RAC. RAC is based on a participant's earned BOINC credits. Credits and RAC are defined by BOINC. These definitions can be found on the BOINC wiki page.[14]

To determine magnitude for a project, the individual participant's RAC is compared to the combined RAC of other Gridcoin team participants, and the number of whitelisted projects.

Future Superblocks

Unique superblock protocols will be created for each platform and stand-alone project added to the Gridcoin ecosystem. The intent is to appropriately distribute GRCResearch-Mint between all platforms and projects based on a participant's relative processing contributions and in accordance with consensus reached by the Gridcoin network.

Blockchain Data

The Gridcoin blockchain currently contains transaction data, held in regular blocks, alongside data pertaining to a network participant's contributions to approved data analytics projects, held in superblocks. These existing functionalities lay the groundwork for a much larger-scale data-storing infrastructure, which could include the following: participant data for sources in addition to BOINC, research data and results, peer-review and scientific journal rating information similar to the contemporary impact factor system, and more.

IPP Distribution

Gridcoin seeks to create an ecosystem of science, research, and data analysis based on the interests of the network's participants. Individuals will direct their IPP to approved projects which they see as beneficial, entertaining, or otherwise of value. A project which benefits or otherwise presents greater value to more people will receive a larger share of the total IPP of the Gridcoin network.

---

14   http://boinc.berkeley.edu/wiki/Computation_credit

Magnitude Economics
Gridcoin's magnitude economics system in conjunction with the different types of data hosted by approved projects makes dated and lower-end hardware competitive with high-end GPUs.

Why Weight Votes?
To prevent an attack on the network through the voting system. If voting was not weighted, an attacker could utilize multiple wallets to vote in polls. If each wallet had an equal amount of voting power, the attacker would be over-represented and skew the poll in the attacker's direction.

To ensure that no single project monopolizes the Gridcoin network's IPP, Gridcoin uses magnitude economics to build a flatter IPP distribution curve. Each approved project is given the same amount of magnitude to split among its participants. This model creates an environment which encourages at least a portion of participants in the Gridcoin network to seek out projects with fewer contributors, ensuring the access of lesser-known projects to significant amounts of computing power.

Infrastructure

The Gridcoin network consists of a collection of interconnected nodes running the wallet software. Each node connects with up to several dozen other nodes. Worldwide distribution of nodes makes the network resistant to disasters like local power outages, natural disasters, or political upheaval, as there is no single point of failure.

Voting

Gridcoin utilizes a voting system built directly into the wallet. Any network participant with a significant stake in Gridcoin (currently 100,000 GRC) can create a poll. Votes can be weighted using a user's GRC balance, contributions to BOINC, or both. Alternatively, a poll can tally votes through a one-wallet-one-vote or one-CPID-one-vote mechanism. A CPID (Cross Project ID) is a BOINC account identifier.

Gridcoin Values

Open Source

Gridcoin software is hosted on GitHub[15] under the MIT license.[16] 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.

---

15   https://github.com/gridcoin/Gridcoin-Research
16   https://opensource.org/licenses/MIT

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 (OER).[17] 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 which are large in scope, such as World Community Grid,[18] as well as smaller projects such as ODLK1.[19]
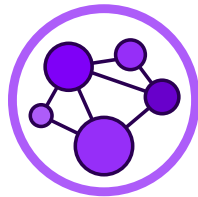
Decentralized Operation

'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.'[20]

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

---

17   http://www.unesco.org/new/en/communication-and-information/access-to-knowledge/open-educational-resources

18   https://www.worldcommunitygrid.org

19   https://boinc.multi-pool.info/latinsquares

20   Johnson, Norman L. "Diversity in Decentralized Systems: Enabling Self-Organizing Solutions." Theoretical Division, Los Alamos National Laboratory, for University of California Los Angeles 1999 Conference "Decentralization Two".

Paid Development
The Gridcoin Foundation currently reimburses approved development in GRC and is equivelant to a rate of $30/hr.

The Gridcoin Network
Community

The Gridcoin network is comprised of blockchain purists, enthusiasts, and coders; established scientific, commercial, or institutional researchers; Ph.D candidates and undergraduates; as well as citizen scientists, data analysts, makers, tinkerers, artists, entrepreneurs, and individuals and groups of all backgrounds. Every participant and developer seeks to advance science, research, and data analytics through blockchain technology, incentive mechanisms, value systems, or by participating in a distributed computing network.

The Gridcoin Foundation

When the Gridcoin protocol switched from proof-of-work to proof-of-stake, there was a set number of GRC which were not claimed during the fork. This GRC was reserved in a wallet designated for development funding. In July of 2017, a reimbursement process was proposed and passed for approved developer contributions.[21]

Development

Gridcoin prioritizes inclusive open-source development that focuses on community involvement and inclusion. While there are a number of core developers who have proven commitment to the project over time, there is no concrete development team behind Gridcoin. Anyone is welcome to propose improvements and changes through the Gridcoin GitHub repositories, and if the changes are approved, they are welcome to seek reimbursement from the Gridcoin Foundation.

Resources
Website and Wallet Software

- **Website and Wallets**
  https://gridcoin.us

Development Repositories

- **Gridcoin Research Client**
  https://github.com/gridcoin/Gridcoin-Research
- **Gridcoin Research Community, for non-wallet based projects**
  https://github.com/gridcoin-community

---

21   https://gridcoinstats.eu/poll/developer_reimbursement_6_month_package

Gridcoin

Block Explorers

- **Gridcoinexplorer**
  https://grcexplorer.neuralminer.io
- **Gridcoin.Network**
  https://gridcoin.network
- **Gridcoinstats**
  https://gridcoinstats.eu

Social Media

Discord
https://discord.me/page/gridcoin

Facebook
https://www.facebook.com/gridcoins

Medium
https://medium.com/@gridcoinnetwork

Reddit
https://www.reddit.com/r/gridcoin

Steemit
https://steemit.com/created/gridcoin

Telegram
https://t.me/gridcoin

Tumblr
https://gridcoin.tumblr.com

Twitter
https://twitter.com/GridcoinNetwork

Other Resources

- **Gridcoin.io**
  https://gridcoin.io
- **Wiki**
  http://wiki.gridcoin.us/Main_Page