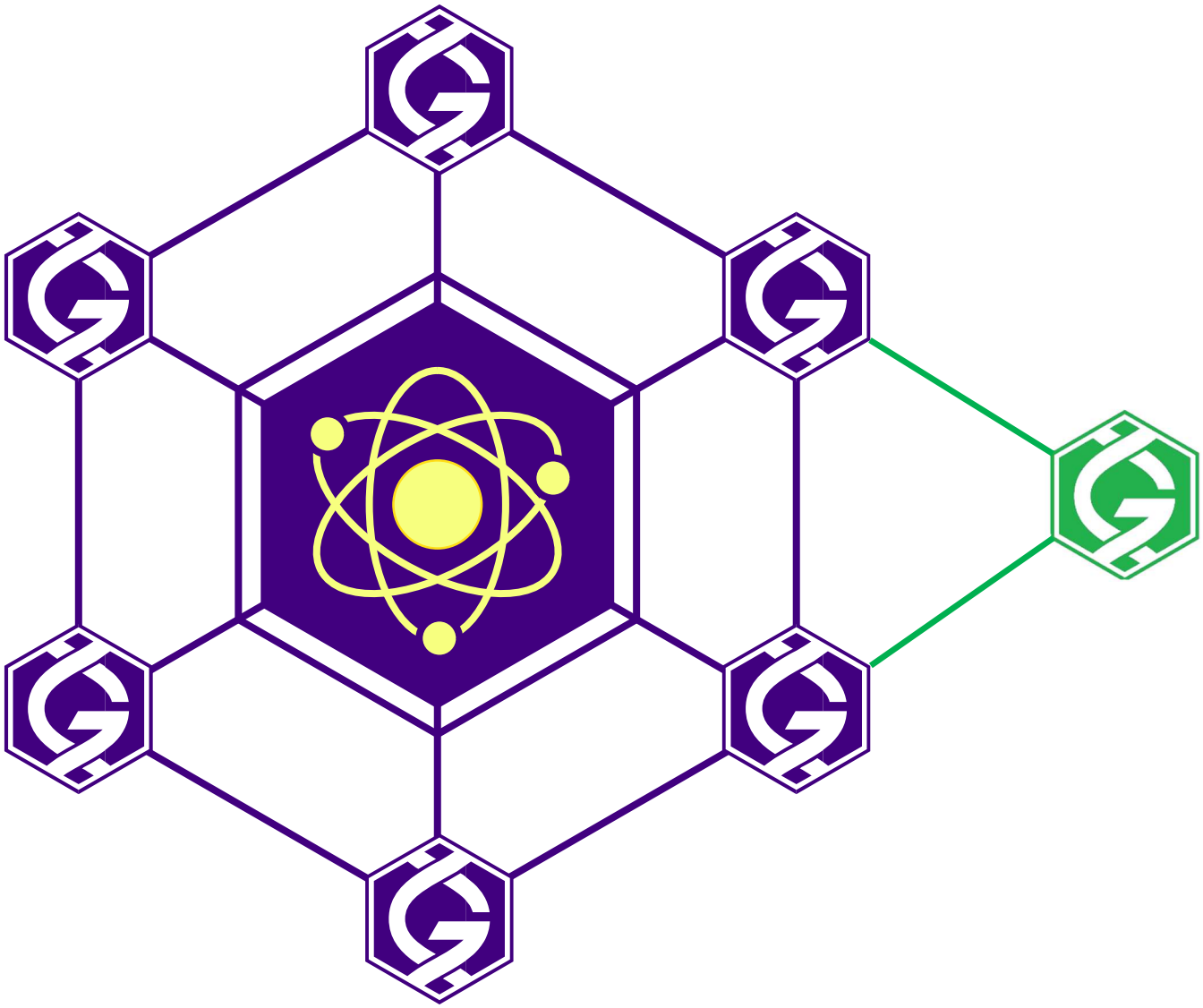

GRIDCOIN GREEN PAPER

A PROPOSAL FOR A CLOSED LOOP ECONOMIC PATHWAY

VERSION 1 (For initial poll)

Gridcoin

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Objective

The purpose of this proposal is to engineer an economic pathway for massively scaling the Gridcoin network. In brief, this involves "greenlisting" computing projects from for-profit companies without awarding them minted GRC. Businesses seeking to purchase computing power from the network would buy GRC and pay directly to their crunchers. For the GRC currency, this would create increased demand, velocity, and eventually price. The ultimate goal is to attract large amounts of Ethereum GPU miners to switch to Gridcoin, benefiting the network and whitelisted science projects. This proposal would require no changes to the Gridcoin code

Disclaimers

There are several criticisms of this idea. I have done my best to anticipate and answer them throughout this paper. I look forward to discussing more with the community. Here are some key things to keep in mind:

1. Nearly all the numbers presented should be thought of as rough approximations. They are accurate to the best of my ability, but many are based on constantly fluctuating measurements (peta-FLOPS of the BOINC network, the price in dollars of Ethereum, etc.). I believe my system is still functional so long as they are within one to three orders of magnitude.
2. Additionally, measurements of total computing power are fraught with difficulties and inaccuracies. Peta-FLOPS are a reasonable approximation but must be understood in light of some serious caveats. Differences in hardware, algorithms, implementations, and even compiler tuning can have a large effect on the efficiency of computation.
3. Much of this paper will discuss prices of cryptocurrencies in dollars, including GRC, and this is at odds with the vision of many leading voices in this community. **I wholeheartedly agree that a myopic focus on price distracts from the truly inspiring things that could be built on an Open Economic Network devoted to science. Those inspiring dreams must continue**. However, a common refrain is "we hope crunchers will come because of greed and stay for the science." This specific proposal is about a way to make the GRC currency profitable in fiat terms for the express purpose of siphoning profit motivated Ethereum miners. That is a prerequisite to a significant expansion of the network and would be an enormous benefit to the BOINC projects we support.

Problem Statements

1. Gridcoin currently trades for about $0.01. It is worth far less than the electricity required to earn the coin. Until this changes, no profit driven miner will switch to crunching BOINC.
2. Gridcoin developers are brilliant and grossly undercompensated. Any proposed solution must be simple to implement and require minimal changes to the codebase.
3. The Gridcoin supply seems to be held primarily by several mostly inactive whales. As they hold a significant amount of voting weight, forking the blockchain and "starting over" is considered off-the-table for this proposal. A solution that leaves the whales untouched is preferable.
4. Complicating this, at least one of the whales may have begun to slowly sell a significant amount of GRC. This has put downward pressure on the price. Any solution must be able to soak up an enormous supply of GRC for demand to finally outpace supply and raise the price.

Some Esoteric Economics Philosophy

[The following is my personal opinion and understanding and should not be taken to represent the opinions of the Gridcoin community at large]. Most cryptocurrencies have a chicken and egg problem. Bitcoin has many properties which make it a useful store of value (scarcity, predictability, divisibility, etc.). However, none of these makes Bitcoin inherently valuable in the way that land is inherently valuable. Bitcoin's value in real, tangible, even dollar denominated terms is derived from the OEN's shared belief in its future value. Bluntly, people are willing to trade goods and services for Bitcoin now because they believe that in the future other people will be willing to trade even more goods and services for those same Bitcoins assuming broad economic growth and a known limited supply of Bitcoin. This chain of network belief works well once established but is difficult to get going. At some point someone must be willing to give up two pizzas for thousands of Bitcoins.

This method of starting a cryptocurrency value chain seems to have a significant first mover advantage. Thus, I prefer to assume that such a value chain is unlikely to ever boost the value of Gridcoin. Instead, GRC's value must be derived from something other than accidents of speculation. Gridcoin is not an investment. One method is to build interesting scientific services on the Gridcoin blockchain which can only be accessed in exchange for GRC (see Disclaimer #3). Examples include scientific paper publication, scientific accreditation, and network governance (voting). A parallel and complimentary method is to inject value into the system by linking the Gridcoin network to existing economic markets, namely the cloud computing industry. One potential implementation of this concept will be described here.

Some "Napkin Math"

Here are some key numbers:

The price that GRC would need to reach ($/GRC) for mining with a GTX 1070 to:

- Break even with electricity costs ($0.10/kWh) = $0.03
- Beat out the least profitable alt-coin on WhatToMine.com (Masari) = $0.04
- Become more profitable to mine than Ethereum = $0.29

Minor caveat – if everyone currently crunching the whitelisted projects simply setup Gridcoin and began getting paid, then competition for magnitude would spike, causing these break-even prices to roughly triple. I view this as unlikely given my research into common attitudes towards profit-seeking in the BOINC community, and so is not considered here.

- Very approximate FLOPS / Ethereum Hash = 250,000
- Hashrate of the Ethereum network at 2018 peak (prior to Eth ASICs) = 73 Exa-FLOPS
- Current Total BOINC power = 27.9 Peta-FLOPS

The Proposal

1. Allow for-profit projects to be granted greenlist status after passing a network poll.[1] These for-profit projects would fund crunching on their project using GRC purchased on the open market.
    a. Greenlisted projects would receive publicity through the initial poll, prominent display alongside Whitelisted projects on Gridcoin websites, and a dedicated Discord channel.
    b. Greenlist status merely denotes the network's public approval of a particular project. There is no way to prevent companies from using BOINC and paying in GRC without going through Greenlisting.
    c. Three months after beginning operations on the network, a company can renew their Greenlist status for an additional three months by paying 20% of the amount they paid to crunchers to the Foundation Fund as a **Listing Fee**.[2,3]
    d. Greenlist status can be revoked by network poll, especially if a business monopolizes excessive amounts of the network's power and decreases power available to the Whitelist.[4]

Optional Additional Efforts (more are listed in Prerequisites and Implementation)

2. Fork the BOINC Client code (https://github.com/BOINC/boinc) and create a Gridcoin branded version. Specifically, the Gridcoin version would allow the Whitelisting Committee to control which BOINC projects appear in the "Add Project" dropdown list. This list should contain only Whitelisted and Greenlisted projects.
3. Allow a Gridcoin non-profit to negotiate the sale of Foundation Fund GRC to greenlisted projects at a price well above market rate (likely $0.29/GRC to begin). This is to get around the relatively low liquidity of GRC on exchanges currently.
4. Establish an alternate GRC ↔ $ pathway on a decentralized exchange like the Stellar network or Uniswap on Ethereum. This would provide additional pathways for the GRC currency and mitigate the risk of de-listing from SouthExchange or TxBit.

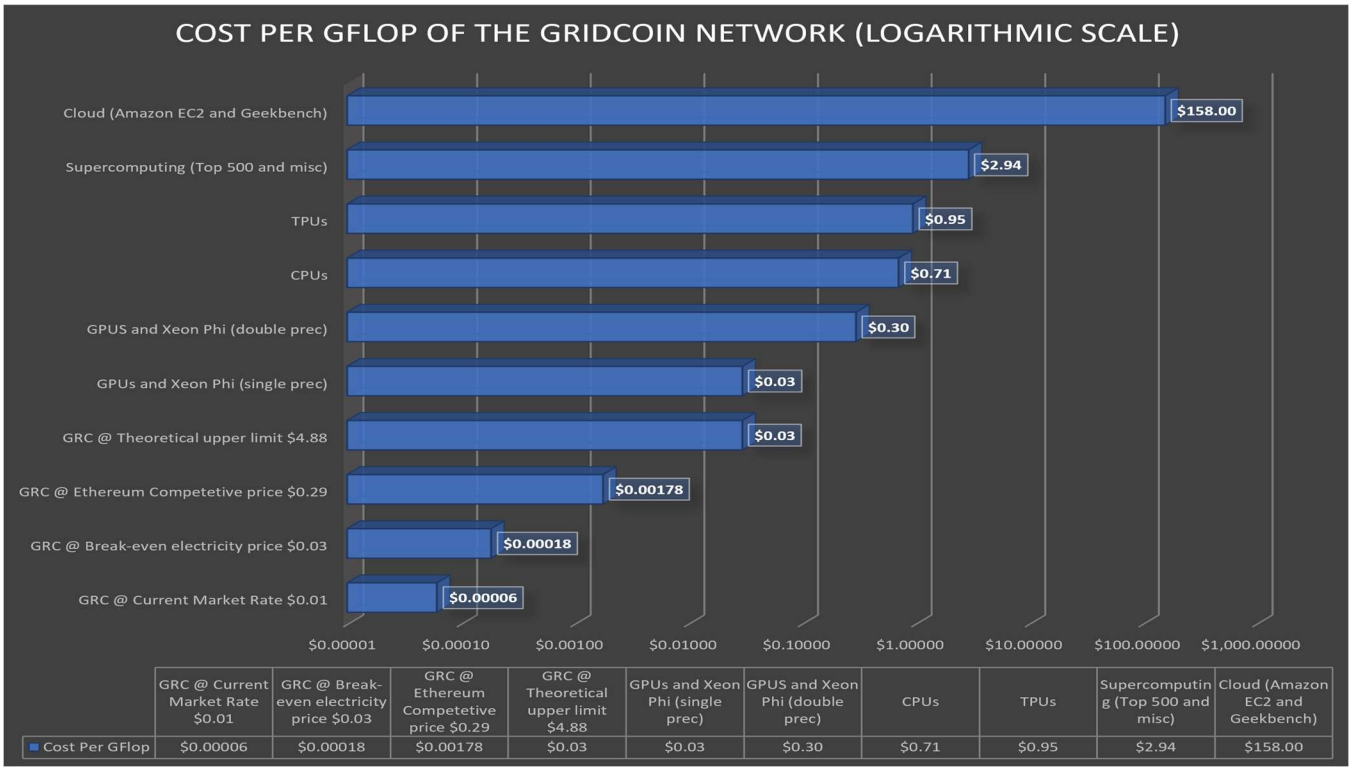
An Example With Numbers

The company Open Science Inc. wants to train an open source Monte-Carlo statistics algorithm which would enable them to make money while solving world hunger. They have some generous angel investors but need access to a lot of power for about three years. For simplicity, let us assume that:

[1] The objective of this proposal is to strengthen the economics of the Gridcoin network for the express purpose of furthering its contributions to science. Any hopeful for-profit company must still go through a community vote to ensure that no project is greenlisted that conflicts with the values of the network as stated in the Gridcoin Whitepaper.
[2] The Listing Fee is likened to the fees paid to companies like Uber and Airbnb for the privilege of using their technology platform to connect buyers and sellers. 20% is roughly equivalent to the fees charged by these two companies.
[3] The initial draft of this proposal included a Funding Limit to protect whitelisted scientific projects from being overwhelmed by deep-pocketed greenlisted companies. Further investigation revealed that this is not enforceable. Further discussion can be found in the "Protecting Science" section.
[4] The initial draft of this proposal suggested using a modified "rainbymagnitude" RPC command to facilitate GRC payments. This has been removed to ensure that the voting power of whitelist crunchers is preserved. Greenlist crunchers receive no magnitude, and thus cannot skew network polls in favor of profit-seeking businesses at the expense of the Whitelist.

- The total number of crunchers on the Gridcoin network stays relatively constant at current levels
- We greenlist only one project at a time
- All 15 whitelisted projects continue to be rewarded with equal amounts of GRC (1/15 of total supply ~= 1,867 GRC/day, ~=680k GRC/year)
- The greenlisted project purchases and funds their crunching with an amount equal to that of one whitelisted project, plus 20% Listing Fees (1,867 x 1.2 = 2,240 GRC/day)
- Open Science Inc. wants to purchase all the required GRC (2,452,800) up front from the Gridcoin Foundation at a negotiated price of $0.29/GRC in anticipation of rising GRC prices and to get around the low liquidity of GRC on SouthXchange.

Using these starting assumptions, it would cost a business $711,312 to rent 364 Tera-FLOPS of computing power for three years. The cheapest alternative would be to buy the hardware and build an equivalent datacenter at a cost of around $12,000,000.[5] The following chart demonstrates the value proposition of the Gridcoin network.



	GRC @ Current Market Rate $0.01	GRC @ Break-even electricity price $0.03	GRC @ Ethereum Competetive price $0.29	GRC @ Theoretical upper limit $4.88	GPUs and Xeon Phi (single prec)	GPUS and Xeon Phi (double prec)	CPUs	TPUs	Supercomputing (Top 500 and misc)	Cloud (Amazon EC2 and Geekbench)
Cost Per GFlop	$0.00006	$0.00018	$0.00178	$0.03	$0.03	$0.30	$0.71	$0.95	$2.94	$158.00

Source for non-Gridcoin comparisons: https://aiimpacts.org/current-flops-prices/
Note : This source is from 2017, Moore's law may have modified the numbers somewhat recently. I believe they are still close enough for rough order-of-magnitude comparisons.

Another Comparison

It should be noted that comparisons and calculations based on FLOPS are notoriously inaccurate. Jim Owens wisely stated once that "a FLOP is not a FLOP" (see Disclaimer #2). To add weight to the argument, I ran a comparison with a similar company, Kings Distributed Systems. I used the makeup of the Einstein@Home

[5] Based on my own calculations and assumptions. This number is in close agreement with that posted on the BOINC Wiki: https://boinc.berkeley.edu/trac/wiki/BoincOverview

project to approximate the total number of CPUs and GPUs attached to each whitelisted project. This came to 8,428 CPU cores and 567 GPUs per project. It would cost $1.5M per year to rent this many CPU cores and GPUs from Kings DS, or 6.5 times the cost of Gridcoin from our hypothetical example above.

How can this be so cheap?

I believe the numbers prove that Gridcoin can take advantage of inefficiencies in the market in the same way that other actors in the sharing economy have found significant market opportunities. The most readily comparable examples are Uber and Airbnb. Both companies are essentially clever technology platforms that enable the economic mobilization of previously underutilized capital resources, namely personally owned vehicles and spare bedrooms. Likewise, Gridcoin is a brilliant technology that enables the economic mobilization of underutilized personally owned processing power.

My Favorite Takeaway from this data:

Ethereum miners are underpaid.

Discussion of Effects on The Network

This proposal as executed in the simple example above would provide several critical things for growing the strength of the Gridcoin network. First, it would provide the Foundation with a sizable amount of dollars with which to pay developers ($0.7M). It would also provide a steady income stream of Gridcoin with which to refill the Foundation Fund, approximately 163,000 GRC per year per Greenlisted project (depending on size). If additional greenlisted projects bought GRC on the open market, demand for the currency would go up considerably and may eventually soak up the excess supply currently being dumped by hopeless whales.

An additional benefit of a more profitable value for GRC is that it would allow a reasonably good approximation for the size of the Gridcoin Foundation's donations to science in dollar terms. At $0.29/GRC, this is $1M worth of computing power donated per project. Being able to attach sizable dollar figures adds weight and credibility to the contributions of the network and would benefit Gridcoin's standing in the scientific community. These figures would be further validated by the fact that for-profit companies would be paying the same amount of money for an equal amount of processing power. Finally, we could argue for acknowledgements in scientific papers produced by whitelisted projects: "This project was made possible by a grant of $1M from the Gridcoin Network."

Eventually, as demand rises to meet supply the price of GRC would rise, first to break even with electricity costs, and later (hopefully) to compete with Ethereum. Best case is that this happens around the same time that Ethereum transitions to Proof-of-Steak and 73 Exa-FLOPS of GPUs are suddenly out of a job. After this, the network could scale arbitrarily to meet market demands for distributed computing power.

Protecting Science

As stated at the outset, the purpose of this proposal is to further the Gridcoin network's ability to benefit science by capturing and diverting market forces. It is important to ensure that as additional projects are greenlisted they do not divert significant amounts of power away from whitelisted projects. This is the reason for the Funding Limit in the original draft of this document. Unfortunately, upon further investigation the

Funding Limit appears to be unenforceable, and companies could easily generate additional RPC payments and attract more crunchers. It is my opinion that this proposal is still safe to implement for the following reasons:

1. Any rational business will try to pay as little GRC as possible for their computation.
2. Allowing businesses to pay as much as they need to attract crunchers enables them to immediately reach profit parity with Ethereum. In other words, if a business was willing, then Gridcoin could start attracting Ethereum miners from day one, instead of waiting for the price of GRC to reach $0.29.
3. This would be less of an issue as GRC becomes more valuable and attracts additional profit-motivated crunchers. As the total power of the network scales up, the amount of power devoted to the Whitelist should increase significantly as well, even if it is ultimately a small portion of the total network.
4. The specter of a monster company monopolizing the network is in fact already present: every Ethereum GPU ought to be doing science. In fact, the situation is worse now because none of them are using the GRC currency, nor are they even running the BOINC client.
5. Many Gridcoin crunchers could earn vastly more GRC right now if they mined Ethereum and bought GRC with it. The fact that they are crunching BOINC instead indicates that they are unlikely to be pulled off the Whitelist solely for increased profit.
6. If a Greenlisted project does cause problems on the network or hurts the power available to the Whitelist, their status can be revoked by network poll.

It is also important to remember that whitelisted Work Units are, in most cases, a limited resource (with the possible exception of Collatz Conjecture). The Ethereum GPUs are, collectively, 8,242 times more powerful than all of Gridcoin. The goal should be to make available to science as much computing power as is needed, and no more. The rest would, ideally, remain connected to the Gridcoin network on greenlisted projects until more science is needed.

Scalable Minted Rewards

The reason for Proposal #1 – Scalable Minted Rewards is to allow for some project's minted rewards to be 0%, i.e. greenlisted, facilitating simpler payment mechanism via the Gridcoin scrapers. An interesting side benefit is that whitelisted projects could have their rewards scaled according to the desires of project administrators. This would enable small projects with relatively limited work units and long time scales to still participate in the Gridcoin network in a whitelisted status. This would be especially important as the total power of the network scales up to prevent smaller projects from running dry and risking becoming greylisted.

A Closed Economic Loop Within the Gridcoin System

Adding greenlisted projects would finally realize a closed economic loop for Gridcoin. GRC is bought by greenlisted companies, who pay it to crunchers for their computing power. Crunchers can in turn sell it to greenlisted companies. Minted GRC would continue to incentive whitelisted scientific projects and would serve as an anchor for the GRC/Computing Power market dynamics (companies would have to closely match their payments to the amounts minted to whitelisted projects to stay competitive). The Foundation would benefit from both the rise in $/GRC prices and the associated Listing Fees, which they could use to pay for increased development on the platform.

A Note on Cheating

For-profit companies that have invested a significant amount of money have a deeply vested interest in preventing and policing cheating. If people can cheat, the company will in effect be getting less computation done for the money they paid. Cheating is not expected to be a significant issue on green-listed projects.

Prerequisites and Implementation

I have done my best to come up with a plan that would require as little development effort as possible. In this form, the concept would not require any changes to the Gridcoin codebase, though several optional ones would streamline onboarding businesses. The bulk of the implementation work would be administrative in nature.

The next steps for this proposal are:

1. Put it to a vote via Gridcoin poll to ensure broad support.
2. Create space on the Gridcoin.world website for displaying the Greenlist.
3. Create a Greenlist section of the Gridcoin Discord.
4. Greenlisting the first project, ideally a business closely aligned to the Gridcoin and BOINC communities.

Optionally, members of the community who are interested in helping this effort can get involved by:

1. Creating onramps for GRC to a DeX such as Stellar or ERC-20/Uniswap.
2. Creating a website that maintains real-time statistics on crunching profitability, to enable listing on altcoin mining websites like whattomine.com.
3. Creating a hardware profiling database so that prospective companies have a detailed picture of the resources available on the network.
4. Creating a test-case BOINC project to develop the knowledge base within the Gridcoin community on BOINC setup and project management.
5. Forking the BOINC Client to create a Gridcoin branded version, with project lists controlled by the Whitelisting Committee.
6. Forming an official Gridcoin 501c3 Nonprofit or LLC.
7. Creating business communication materials such as flyers, presentations, and websites.
8. Advertising and reaching out to interested businesses.
9. Advertising to Ethereum (and altcoin) miners.

Possible First Candidate

I have thought of one possible company that may be promising as an initial candidate. I am sure the Gridcoin community will think of many more. The Numerai project is a hedge fund which incentivizes data scientists to create machine learning models that can predict movements in the stock market. Competitors are paid in the Numeraire (NMR) ERC20 token. Anecdotally, the very first winner of the weekly competition (several years ago) was paid about $100 for his winning contribution. He laughed and said “I spent about 20 times that much on the compute to generate that model!” The Numerai community is intimately familiar with cryptocurrencies, computer science, and cloud computing, and could bring many brilliant minds into the Gridcoin space. Their machine learning models may be able to benefit from increased computing power. Implementation would be difficult since there are hundreds of data scientists training and competing different algorithms. The Numerai company or community would have to setup a centralized BOINC server which would accept work units from

the data scientists and distribute them to the Gridcoin network. They recently released their updated Numerai-Compute framework for automating certain associated aspects on Amazon Web Services, but they have expressed interest in extending this to the Golum distributed computing project as well.

A note on why training AI on Gridcoin is not likely…

The Numerai machine learning tasks mentioned above may work given their relatively small size. An extremely large machine learning project on par with GPT-3 is not possible to achieve on a highly distributed, low bandwidth system like BOINC and Gridcoin. The Eleuther project is an open-source competitor to GPT-3, and this particular problem is addressed in their FAQ here (https://www.eleuther.ai/faq/):

"Q: What about volunteer-driven distributed computing, like BOINC, Folding@Home, or hivemind?

A: We have considered the possibility of pooling volunteer resources for training models, but upon thorough review, we have concluded that such approaches are not a viable option today. There are numerous problems with current distributed approaches for us:

- *Backpropagation is dense and sensitive to precision, therefore requiring high-bandwidth communication.*
- *Mixture-of-experts-based models tend to significantly underperform monolithic (regular) models for the same number of parameters.*
- *Having enough contributors to outweigh the high overhead is infeasible.*
- *Verifiability and resistance to outside attack are not currently possible without significant additional overhead.*

In short, doing volunteer-driven distributed compute well for this use case is an unsolved problem. If you have expertise in this area, drop us a line and we will be happy to hear you out."

Possible Second Candidate

Likely further afield, the prospect of greenlisting a power company would have even more interesting use cases. In 2019, a large utility company in France, EDF, began working with iExec, a "decentralized marketplace for cloud resources" which uses RLC as its native token.[6] What this demonstrates is that large utility companies may have significant requirements for computing power. A greenlisted utility company may be willing to take GRC as payment for electricity consumption, adding a fascinating layer to the closed economic loops within the Gridcoin economy.

Downsides to Gridcoin

In its current implementation, Gridcoin is most easily applied to projects built on the standard BOINC infrastructure. This is by no means a requirement, and could change soon, however BOINC was not designed with much consideration for data security and privacy. A company with even the slightest desire to ensure the security of proprietary business data and algorithms will likely not choose Gridcoin. Marketing and advertising would have to focus on companies friendly to open-source principles.

The Gridcoin system works best on large, long-term computation projects (greater than one month). The process of polling and greenlisting as well as BOINC's RAC "charge up" formulas would make operating shorter-

[6] Utility Giant EDF Deploys Blockchain Application on Ethereum and iExec

term projects difficult if the “rainbymagnitude” RPC command is used. This could be mitigated if a company chose instead to pay GRC by another metric, for example raw credits earned (1 credit = 1 GRC). In this case, they would have to implement a custom payment system to translate between their BOINC server credits and the company Gridcoin wallet.

Gridcoin is open-source and could be easily duplicated without the inflationary mint boosting scientific projects. A network identical to Gridcoin without the mint would be cheaper to rent than Gridcoin. Gridcoin’s only advantage in this case is it’s first-mover status and sizable pre-existing network.

Summary

Purchasing computing power on the Gridcoin network is several orders of magnitude cheaper than any alternative. Selling a portion of the network’s computational power to respectable for-profit companies would re-fund the Foundation, increase and stabilize the value of the GRC currency, and provide closed economic flows to the Gridcoin economy. Ideally, this may facilitate the capture of a large portion of the Ethereum network’s GPU infrastructure…for science.

Closing Remarks

Many thanks to J-Ringo, Jim Owens, RoboticMind, ILikeChocolate, and the many other Gridcoiners that encouraged me to dive in and contribute some ideas.

If you thoroughly enjoyed this paper and simply must tip the author, here is my wallet address:

S1fSQwAJD5bzBCucsCRs6kPUCwhfGAEEFt

But most of all, I hope you generate your own better ideas and share those back. Sincerely,

-AgentP