The Modern Talent: An Earth-Backed Democratic Digital Currency System

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Abstract

Modern economies issue new money primarily through two mechanisms: commercial bank loans and central bank purchases of sovereign debt and other assets. Because most humans now depend on fiat money for survival, power invariably concentrates into the hands of those who apportion currency, institutionalizing corruption and inequality. As the life support systems and biodiversity of Earth rapidly degrade, human population, resource and fuel consumption, mass extinctions, and climate change increase unabated, threatening our species and the entire planet with collapse on an unimaginable scale. All of these problems are considered external to accepted macroeconomic theory, which relies on growth and posits substitution as the solution to extinction and degradation.

To mitigate currency's role in this destruction, I propose a worldwide scalable, distributed and peer-to-peer, democratically influenced, Earth-backed digital currency network independent of state, bank, and corporate control, called the Talent Network. The system consists of many regional currencies, several world currencies and measures, and a global reserve, the Modern Talent. Regional money will be created solely through monthly income payments for adults in the region. The Modern Talent functions primarily as reserve currency for the regional currencies.

To tie the network to planetary health and change entrenched perceptions of money, each regional currency will have a demurrage rate determined by the weighted rate of change of environmental and human welfare factors in the region. Factors and weightings will be transparently determined and influenced by a democratic vote of regional participants. The demurrage rate of the Modern Talent will be linked to annual atmospheric CO_2 equivalent change.

All currencies will have transparent transaction chains through a modified blockchain implementation. As a result, the network is public for all participants.

I explain the problem, currency network, challenges in implementing it, and next steps.

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1. Introduction

Planet Earth is undergoing a great[2] crisis. The ocean's fisheries are in collapse (Pauly & Zeller, 2016); coral reefs are dying (Jackson et al., 2014); the global extinction rate is as much as 100 times what would constitute a normal rate (Ceballos et al., 2015); and CO_2 equivalents in the atmosphere are 30% higher than pre-industrial levels, and rising at an accelerating rate (NOAA Earth System Research Laboratory, 2017). The present atmospheric CO_2 level of approximately 410 ppm recently observed at Mauna Loa (NOAA Earth System Research Laboratory Global Monitoring Division, 2017) was likely last seen on Earth between 10 and 14 million years ago, perhaps longer. During that middle Miocene period temperatures were between 3 and 6 degrees C warmer than the present, and sea levels 25 to 40 meters higher than the present (Tripati et al. 2009). Such changes, even if they take several centuries to occur, will radically transform life on Earth, threatening human civilization and perhaps the survival of the human species, should a 'runaway' effect transpire.

The present and predicted loss of biodiversity will also have far-reaching and unforeseen consequences. We cannot adequately predict how the loss of species may impact humanity. The interdependent nature of eukaryotic life on Earth suggests, however, that conventional utilitarian analysis of this biodiversity likely fails to fully describe the harm. As the number of species is reduced, the entire web of life becomes more vulnerable to sudden shocks and disequilibration. The atmosphere is part of the biosphere, and as the biosphere changes, so too will atmospheric composition. As just one example, all aerobic animal life on earth depends on plant life for its survival, both for food (either directly or indirectly) and for respiration, as plants convert carbon dioxide (CO_2) to oxygen (O_2) as they photosynthesize. Between 50 and 85 percent of all atmospheric O_2 is produced by oceanic phytoplankton (EarthSky staff, 2015); were these organisms to stop photosynthesizing, a scenario predicted by some models with a temperature rise of just 6 degrees C (Sekerci & Petrovskii, 2015), all of Earth's aerobic life could face extinction as atmospheric oxygen levels dropped.

At present, mainstream economists, large corporations, the world economy, and the interlinked nation-state economies mostly ignore these issues, treating environmental welfare as external to the economic production-consumption cycle - what economists call an 'externality' - and therefore the sole responsibility of regulators. It is a widely accepted belief, then, that governments must bear the responsibility of limiting and reducing the ecological harm caused by human economic activity through regulation; but this model fails for several reasons:

- The dependence of governments on economic production to support fiat currency values and to collect tax revenues causes woefully inadequate or toothless regulating.
- The profit motive for corporations provides encouragement to cheat or push the boundaries on any regulations that are enacted, and to lobby governments for reductions in regulations, turning environmental costs back into economic externalities.
- Due to the dominant belief of the world's citizenry that conventional economic activity is necessary for their survival and livelihood, regulating to protect the environment is perceived by a significant segment of humanity as a threat to their own prosperity.

[2] Great when examined against the fossil record, ice core record, and the five known great extinctions.

All modern fiat currencies contain fatal flaws that make them incompatible with long-term life on Earth. Their present design undermines any chances for a sustained prosperous existence for humanity.

On of the fundamental flaws is modern banking. The overwhelming majority of modern money is created through banks, as loans. Loans are made to those who banks judge have the ability to amass sufficient capital to repay, including the interest payments on their loans. Thus nearly all money enters the world economy as debt (Douthwaite, 2000). It follows that a stable (i.e., non-deflationary) money supply in such a system requires economic growth. Unfettered exponential economic growth (interspersed with periodic recessions) protects capital and banking and concentrates wealth, so modern governments, central banks, and media pundits promote it as necessary and beneficial, in spite of the disastrous consequences on the life support systems and species of Earth. This includes the negative effects on the overwhelming majority of humanity.

Governments spend money through the choices of politicians. When privately held money is permitted to influence government, government spending adjusts to reflect the desire of the moneyed elite to retain and increase their wealth and power. Thus wealth is further concentrated and democracy is undermined. Tax policy then grows to reward investment over labor. In such a system, a tiny fraction of people live lives of extreme wealth and privilege, while the vast majority struggle to survive, living paycheck to paycheck. Those already possessing sufficient capital to 'live off the interest' can increase their holdings at will by lending or investing, activities that require virtually no labor and which can be tailored to minimize risk.

Mainstream environmental economists attempt to address issues of negative environmental externalities using traditional economic terminology and methods. Doing so ignores the fact that modern economics is a cultural discipline with certain sacrosanct myths underlying its foundation. It is not grounded in physical science nor founded on experimental principles, and is therefore not based on empirical reality.

Monetary systems are similarly a cultural phenomenon. Why are currencies primarily cultural? Because they bind groups of people together with a shared myth - in this case, the shared myth is about what constitutes value and has worth. The value notions associated with modern money are ones that arose hundreds or thousands of years ago, in medieval European societies, the Roman Empire, ancient Greece, and, further back in time, in the early agrarian societies in what we now refer to as the Middle East (Grierson, 1978). These value notions formed at a time that predates modern technologies, when the planet seemed a vast and even limitless place, providing an endless supply of resources. For all intents and purposes, this was true. Greater value was assigned to those things that were scarce and that humans wanted at that time, such as gold and spices, and of course stored food.

From a practical standpoint, the planet is not and can no longer be seen as limitless. The perspective on what has the greatest value to humanity must consequently shift. The present model of currency distribution perpetuates a culture and lifestyle that destroy the planet's life support systems, concentrate wealth, and impoverish much of the planet's human population. We must create a currency system that recognizes that the greatest worth is in that from which we all arise, and that we are not separate from it.

2. Talent Network: A New Network of Currencies

The Talent Network will function as a loose network of currencies, directly connected to environmental and human welfare, without the centralized control or concentration of power and resources that plagues present day fiat currencies, and without the problem of environmental externalities. It consists of:

- A single *global reserve currency*, the *Modern Talent*, which is connected to atmospheric CO_2 and CO_2 equivalent gas concentrations in the atmosphere;
- Three other *global currencies*, each of which is tied to a separate measure of planet-wide health;
- Nine *global measures* of environmental health and human welfare that aggregate regional data;
- An undetermined number of *regional currencies*, each of which is tied to localized environmental health and human welfare measures that are weighted according to a democratic process and distributed as conditional basic income for regional citizen participants.

The complete network functions as more than just an alternative currency system. It provides a way to understand planetary health and its momentum, and the means by which Earth health can enter the public consciousness and popular culture. Feedback mechanisms in the system connect the world economy to the Earth, from which all human enterprise arises, and to the health of the Earth's living systems, on which all humanity depends.

Measure	**Boundary Level**
Climate Change	CO_2 concentration in the atmosphere <350 ppm and/or a maximum change of +1 W/m^2 in radiative forcing.
Ocean Acidification	Mean surface seawater saturation state with respect to aragonite ≥ 80% of pre-industrial levels.
Stratospheric Ozone	<5% reduction in global stratospheric O_3 concentration from pre-industrial level of 290 Dobson Units.
Biogeochemical Nitrogen (N) and Phosphorus (P) Cycles	Limit industrial and agricultural fixation of N_2 to 35 Tg (Teragrams) N/yr; annual P inflow to oceans not to exceed 10 times the natural background weathering of P.
Global Freshwater Use	<4000 km^3/yr of consumptive use of runoff resources.
Landsystem Change	<15% of the ice-free land surface under cropland.
Rate of Biological Diversity Loss	Annual rate of <10 extinctions per million species.
Chemical Pollution	Boundary level undefined.
Atmospheric Aerosol Loading	Boundary level undefined.

Table 1. Measures and Planetary Boundary Levels as proposed by Rockström, et al. (2009)

Excepting the human welfare and nonproliferation measures, each global currency and measure is based on one of nine *planetary boundaries* proposed by Rockström, et al. (2009) (Table 1). Rockström, et al. proposed *boundary levels* for the first seven of those nine. The boundary levels are meant to establish a

safe distance from dangerous levels, or from thresholds beyond which nonlinear transitions to new equilibrium conditions are likely. When a boundary is crossed, it implies radical changes to the planet and its life support systems. The authors of that study were unable to establish firm boundaries for the final two, chemical pollution and atmospheric aerosol loading, due to a general lack of research and understanding of the long-term global effects of both.

In the Talent Network currencies, the boundary levels are used as input to demurrage rate curves. In this way the demurrage rate for each currency reflects the changes occurring in the real world. Demurrage rate changes impact both currency value and money velocity and are discussed in the section on demurrage.

2.1. Global Currencies

The four *global currencies*, named in Table 2, correspond with the original planetary boundary measures in the second column. The first, the Modern Talent, is a *global reserve currency*, whose function is explained more in the corresponding section that follows. The Ocean Aragonite and O3 currencies are non-reserve global currencies and are not derived - i.e., they are completely independent of regional currencies, and their levels must be determined from public data collected from scientific instruments such as field sensors or satellites. The Bio currency is partially derived, with regional currency data on extinctions providing the input for the extinction rate of land and regional water body plants and animals; while the ocean-based extinction rate component must be determined independently.

Global Currency Name	**Corresponding Planetary Boundary Measure(s)**	**Metric(s)**
Modern Talent (Global Reserve Currency)	Climate Change	1) CO_2 equivalent concentration in the atmosphere. Measure includes non-CO_2 GHGs such as methane. 2) Change in radiative forcing, measured in W/m^2
Ocean Aragonite	Ocean Acidification	Mean surface seawater saturation state with respect to aragonite (Ω_{arag}).
Bio	1) Rate of Biodiversity Loss (Land-specific) 2) Rate of Biodiversity Loss (Ocean-specific)	1) Metric derived from Biodiversity component of regional currencies. 2) Extinction rate in oceans (in extinctions per million species-years (E/MSY)).
O3	Stratospheric Ozone	Stratospheric O_3 concentration in Dobson Units.

Table 2. Talent Network Global Currencies.

Initially the three non-reserve global currencies - Ocean Aragonite, Bio, and O3 - will be distributed only to data providers/miners of those currencies, similar to some modern day cryptocurrency issuances. However, an important distinction is that these currencies will, like the Modern Talent and the regional

currencies, have a demurrage rate that is based on the rate of change of their metrics[3]. Therefore under present-day circumstances all three will lose value over time, reflecting underlying environmental damage. The O3 measure will likely lose value at a slower rate than the other two, however, as anthropogenic activity causing stratospheric ozone depletion has for the most part been halted, and ozone depletion has slowed (Rockström et al., 2009).

2.2. Modern Talent - Global Reserve Currency

The Modern Talent as global reserve currency will flow on demand to the individual humans who are approved regional currency participants, thus acting as direct supplemental income. The term 'reserve currency' in this case is conceptually different from the present world reserve currency, the SDR (Special Drawing Right, a creation of the International Monetary Fund). SDRs derive their value from a calculation based on a basket of fiat currencies (International Monetary Fund, SDR Valuation, 2017) and an SDR-fiat exchange policy enforced by the IMF on its members (International Monetary Fund, Factsheet: Special Drawing Right SDR, 2017). SDRs were originally created by the IMF under the Bretton Woods system to supplement gold and dollar reserves, but in the present-day floating exchange rate (fiat currency) regime, they are distributed by the Bank of International Settlements to central banks when there is risk of a liquidity crisis. The average human does not directly benefit from the existence of SDRs; individual benefit is theoretically derived from the stability afforded that person's native currency through SDR protection.

Talents remove the unnecessary intermediaries from the reserve currency process.

The Modern Talent will rely on conforming regional currency identity verification procedures to determine who can be added as a valid Modern Talent participant. All human members in conforming regional currencies are eligible to receive talents. Any organizational participants (corporations, governments, etc.) of regional currencies are not eligible to receive a regular allocation.

The number of talents available to each human member will be set annually. A total pool of talents is determined based on atmospheric mass, which is then discounted using atmospheric CO_2 equivalent levels beyond pre-industrial levels, with greater weighting on amounts exceeding the boundary condition of 350 ppm. This amount is then divided by the population of the planet on the annual calculation day to arrive at an individual allocation amount. More details on distribution of talents are in Currency Issuance and Destruction.

2.3. Global Measures

The global measures (Table 3) are interpolated and derived by aggregating regional currency data. In an initial implementation, these measures will be calculated and published as global totals but will not have a currency distribution mechanism. As global metrics, they are (initially) for informational purposes. However, in order for a region to be a legitimate Talent Network participant and for its participants to have access to Modern Talents, the regional currency must collect data and incorporate all global measures into it. Since all regional participants will have access to Modern Talents as a personal reserve

[3] Along with the boundary levels for the underlying measures, where they exist.

once their regional currency meets the basic criteria, it is in the interests of participants to incorporate all global measures into their local currency.

In a later implementation, as the regional currency network grows to encompass the entire land surface of the planet, the global measures may become full-fledged currencies with their own distribution plan.

The Chemical Pollution, Aerosols, Human Welfare, and Nonproliferation measures are each complex, so that creating a single numeric value for each is not possible without making subjective assessments of relative importance. The details of what metrics comprise each measure and their relative weightings should first be determined by regional currency participants. To arrive at an overall global standard for each, a 'wisdom of the crowds' approach (Surowiecki, 2005) or a 'wisdom of artificial crowds' artificial intelligence heuristic (Yampolskiy & El-Barkouky, 2011) can be utilized to determine the key elements that should comprise each global measure based on the composition of each equivalent regional measure. Once a global standard is finalized for each measure, regional currencies must begin providing data for the global measures according to the standard, but can retain their own weightings and composition for these measures within the confines of the regional currency.

Global Measure Name	**Corresponding Planetary Boundary Measure(s)**	**Metric**
N	Biogeochemical Nitrogen (N) Cycle	Industrial and agricultural fixation of N_2, measured in Tg (Teragrams) N/yr.
P	Biogeochemical Phosphorus (P) Cycle	Annual anthropogenic P inflow to oceans, measured in Mt (Megatonnes) P/yr.
Freshwater	Global Freshwater Use	Consumptive use of runoff resources measured in km^3/yr.
Land	Landsystem Change	Percentage of the ice-free land surface under cropland.
Chemical Pollution	Chemical Pollution	Undetermined and complex; measure should focus on observed effects on known sensitive organisms (e.g., amphibians) and humans.
Aerosols	Atmospheric Aerosol Loading	Complex, comprised of multiple metrics.
Human Welfare	N/A	Complex, comprised of multiple metrics.
Nonproliferation	N/A	Complex, comprised of multiple metrics.

Table 3. Talent Network Global Measures. Blue measures have well-defined metrics; white measures are complex and will first be defined by regions before developing global standards.

2.4. Regional Currencies

Each regional currency is associated with a bounded geographic location where humans live. Existing national boundaries may suffice as regional boundaries in most cases; in the case of geographically large

countries (Canada, US, Russia, China, Brazil, Australia, and possibly others), states or provinces may be more suitable as regions. When the land area of a region is smaller, such as a US state or small European country, it means that the environmental changes and economic impacts that affect regional currencies will be more consistently apparent in the individual experiences of the region's members than they would for a large region like the entire United States, where a great deal of variation can occur. Smaller regions are better at allowing people to connect what they see daily with what happens to the currency (Douthwaite, 2000).

Unlike the global currencies, regional Talent Network currencies are complex, meaning they are based on a basket of factors rather than a single measure. Each regional currency has the challenging task of quantifying the overall health of the region in order to establish a regular currency issuance amount and a demurrage rate. Agreeing on a methodology to determine what constitutes a region's health is difficult; measuring it even more so. Given the uncertainty and element of subjectivity, such decisions should be made collectively by all currency participants, rather than by a minority or oligarchy. In other words, they must be decided democratically.

For a regional currency to be included in the network (and for its members to have access to Modern Talents) it must incorporate ongoing measurements of all of the metrics that comprise the global measures, as well as regular measurements of regional biodiversity loss, which will be included in the global Bio currency. Thus, at minimum a regional currency implementation must include regular tracking of the following measures:

- Bio
- N
- P
- Freshwater
- Land
- Chemical Pollution
- Aerosols
- Human Welfare
- Nonproliferation

Because the last four of these measures are complex and their details undefined, it will be up to the members of each region to define them for their currency. Once enough regions have defined these measures, a global standard can be developed.

A regional currency must meet certain additional requirements for its members to participate in the global reserve system. The complete requirements are:

- It must collect accurate, independently audited data for each of the above measures, and incorporate these into the currency's blockchain with either the push or pull method described in the section on data collection.
- It must be a blockchain-based (i.e., distributed ledger) currency. In other words, no organization, entity, or single person or small group of persons may control or influence the currency's transaction ledger or distribution mechanism.

- It must be democratically influenced. Regional currency participants must collectively decide on such things as:
    - Any measures that will be in the currency basket that are not part of the original template and are not required by the Talent Network.
    - The relative weights of the measures that comprise the currency basket. These weightings must be freely available and public information.
    - The elements comprising each of the complex measures, and the weightings of each element in calculating the overall measure.
- Once established, only through a democratic vote of all participants can the currency rules change.
- The primary mechanism for currency distribution must be regular payments to verified adult human participants (discussed further in Currency Issuance and Destruction).
- The currency's weighted measures must directly determine its demurrage rate, which must reflect both the annualized change to regional health as well as performance relative to boundary levels for component measures.
- Individual participation must be voluntary.
- Information on all parties to a transaction must be freely available to any participant, making all transactions public.
- The currency must not be lent into existence by banks or other lending institutions; i.e., fractional reserve lending in the regional currency must not be sanctioned.

Template software for regional currencies will be developed and used in the trial implementation. The template will be fully functional and will include all of the mandatory elements necessary to connect a regional currency to the Talent Network.

A fundamental goal of the regional currencies and the Talent Network as a whole is to shift economic and cultural behavior toward long-term sustainable practices, so that each region can sustainably support the humans living within its boundaries while preserving the remaining ecosystem and ensuring its health in perpetuity. To sustainably support means to support without drawing down any non-renewable resources, or reducing the stocks of renewable resources, or harming the natural systems of the region at a rate greater than their ability to repair themselves. Resource substitution is ignored, because to eliminate a resource implies that something was mined, burned, cut down, or polluted to the point of exhaustion, and this is incompatible with long-term sustainability.

If at some point it becomes obvious to participants that a currency is not achieving this primary goal, then the rules governing it must be changed, or it must be replaced.

3. Implementation Details

3.1. Decentralized Digital Implementation

The Talent Network currencies have much in common with bitcoin in their implementation:

- They will use a distributed transaction ledger, or blockchain, that builds on the model established by bitcoin.
- They will use a decentralized peer-to-peer network to prevent any one node or group of nodes from controlling the blockchain or fabricating information in it.
- The nodes that run the blockchain and validate blocks will, for the foreseeable future, receive a reward in currency, similar to bitcoin miners.
- Individual participants will have an address or addresses and a private key or keys that they can hold in a digital wallet that they will be responsible for securing. These addresses are where their currency is located.

Unlike bitcoin, however, Talent Network currencies will have the following properties:

- *High scalability*. The Modern Talent must scale to function as a secondary currency for all human inhabitants of Earth. The Talent Network currencies must eventually scale to support billions of transactions per day in aggregate. This will primarily be through the regional currencies, which individually need support a smaller amount proportionate to their population. The initial instantiation of the network (all currencies combined) should be theoretically capable of supporting millions of transactions per day[4], and in practice capable of supporting hundreds of thousands per day; block size and other limiting factors must be adequate to accommodate this, while still maintaining the integrity of the peer-to-peer network. The design of the blocks and the blockchain, as well as the proof-of-work component of data providers' submissions, must take into account the need for robust scaling. The bitcoin community at present has not adequately addressed scaling issues.
- *Block design contains measurement and demurrage data and is expandable*. The currency block will contain more information than bitcoin since all measurement data will be inside the block. It must be designed to minimize the bitcoin 'hard fork' problem, in which all miners must adopt a new software version or the transition will fail (Back et al. 2014). This means that planning for the content of the currency block is critical, and should be guided by the results and lessons of the Talent Network trial implementation and of existing cryptocurrencies. When hard forks are inevitable, the process of updating software should be smoother and more coordinated than the process for bitcoin. Pegged sidechains, as proposed by Back et al. (2014), could provide a reasonable path to long-term upgradability for Talent Network currencies.
- *Signed and transparent, without expectation of anonymity*. The Talent Network currencies will use a unique identifier for every individual (and organization, where applicable) that participates in the system. This identifier must be incapable of being faked, spoofed, stolen, or misused, since it is directly connected to a person's reputation and spending. Identities must be validated to receive an identifier, and all identities will be publicly available. At any time, any participant in the system will be able to query the identity of a participant and all of the transaction history

[4] In other words, no element of the design of the individual currencies should hinder or obviously restrict transaction volumes, as is the case with bitcoin.

associated with an identity, including amounts and payors/payees. All organizationally initiated transactions, without exception, will carry a signature identifying the person responsible for that transaction, in addition to the organization's signature, to prevent 'hiding' behind an organizational identity.

- Data providers *are the equivalent of bitcoin miners, but have greater responsibility than bitcoin miners*. They both supply measurements and run the blockchain. Data for the global currencies that is not derived from regional measures can be collected via either a push or a pull strategy, depending on the efficacy of each method in trial runs. A similar method can be used for the regional currencies. The push and pull strategies are described more in the two subsections below.

3.1.1. Data providers - push strategy

If a currency uses a push mechanism, data providers are rewarded by the network in currency for being the first to contribute a measurement that is unique, valid, and valuable, as confirmed by other data providers. Data providers must also run the blockchain software - thus creating the currency network - for the particular currency for which they are providing data, and (possibly) solve a cryptographic hash when contributing a block. This is similar to the way that miners are rewarded by cryptocurrency networks, though only for solving a hash and contributing a block.

In this strategy, contributing a measurement is a necessary element of adding a block. Providing measurements from verified sources, along with calculating a new overall value for the metric and demurrage rate for the currency based on the new input, can either take the place of cryptographic hashing, or can be combined with a lower complexity[5] cryptographic hash for a two-part block validation. In this case data providers are rewarded in currency for providing a validated measurement and performing the calculations and the hash when they run the blockchain software. Just as the hash is validated by peers, each measurement must be validated by peers in some way. Validating the hash is relatively easy; the winning miner simply broadcasts its solution to the hash, and other miners confirm that the solution is correct. Validating an environmental or human welfare measurement through software is more difficult, but should be possible. This is especially true given that anonymity is not an aim of the Talent Network, and the humans who own data provider nodes are limited to one instance each.

While I will not endeavor to solve the measurement validation problem for all currency types here, consider the following example for the Modern Talent (CO_2 and CO_2 equivalent-based global reserve currency):

A data provider submits a block to add to the talent blockchain. That block contains the following data:

- A number of payment transactions, as in a bitcoin block;
- A block header that, in addition to the standard bitcoin header data, contains:
    - A CO_2-only measurement originating from a verifiable CO_2 measuring device in a verifiable surface, air, or satellite location. For instance, a tall tower CO_2 measurement

[5] Lower complexity and less computationally taxing than bitcoin, because of the much more stringent scaling requirements in the Talent Network.

would include a UTC timestamp, a value in parts per million, and an exact geographic location and altitude;
    - A measurement station validation protocol;
    - A new calculation of overall atmospheric CO_2 equivalent level based on this new measurement, the previous metric value, and recent measurements already present in the Modern Talent blockchain, from disparate sources and locations and including the other greenhouse gases;
    - A new calculation of the currency demurrage rate based on the new overall atmospheric CO_2 level;
    - A hash satisfying the difficulty requirements for the currency. Hash difficulty should be lower than Bitcoin hash difficulty.

Other data providers (network peers running the blockchain software) confirm the validity of the hash. They then confirm the validity of the measurement from the winning data provider through a measurement station validation protocol, either through direct contact with the station or as sent by the block winner. Location validity is important for CO_2 readings and is considered when validating the measurement. For instance, a reading taken inside a building, near a busy freeway, or even simply at ground level in any populated area, is worthless for determining overall atmospheric CO_2, even from a validated instrument. Only readings taken from select locations[6] can be considered valid.

The validation protocol will consist of proof of measuring equipment used, proof of measuring equipment location (height above surface and altitude, geographic location, or satellite identification), proof of measuring equipment calibration, and some minimum history of valid readings from this location and equipment. Station spoofing is a concern with this method; data provider stations must be able to be initially verified at an exact GPS location and altitude, and the measuring equipment verified and calibrated as well. A unique public-private key identifier can be given to the data provider's selected site after passing initial site validation and this ID then used as a partial site validation shortcut.

Finally, the peers validate the metric and demurrage rate calculations.

If a data provider is using publicly available data such as from a website, rather than from their own instrument, the validation protocol must include validating the website as well as checking the submitted data against the data on the website. An example would be the satellite datasets available from NASA.

A timeout period should be enforced for both a data source and provider after winning a block to prevent network hijacks and improve data quality.

[6] At present, baseline atmospheric CO_2 measurements are taken in Tasmania, in Barrow, Alaska, in Samoa, in Antarctica, and at the summit of Mauna Loa, Hawaii. Tall tower measurements for the NOAA Earth System Research Laboratory Global Monitoring Division program are taken from a number of sites in North America (site data is available at https://www.esrl.noaa.gov/gmd/ccgg/insitu/index.html). Satellite data on atmospheric CO_2 concentrations is also available.

The remaining challenges of the push method lie in determining what makes a validated measurement both unique and valuable - both of which are necessary in order to ensure data quality when calculating an overall measure value and a demurrage rate.

3.1.2. Data providers - pull strategy

If the currency uses a pull mechanism to retrieve data, someone must take responsibility for identifying legitimate data sources from which measurements can be pulled, and then link these sources to the currency. In this case the blockchain software is run by all recipients as a requirement to receiving currency. Data providers are not rewarded, but the person who identified and linked the source may be.

The drawback of the pull method is that some individual or group makes initial decisions about what constitutes a legitimate data source, and is responsible for updating data sources if they become outdated or invalid. The legitimacy of the source can be confirmed through a network vote, but the task of finding a source and updating it when necessary is still left to someone who is 'working for' the currency network, and using his or her own heuristics to choose sources.

In the long term, the push mechanism is likely preferable if the challenges to determining in software what constitutes a legitimate measurement can be solved, since it incentivizes data providers who use the currency's API to insert a measurement into the system. The pull mechanism risks breakage with any change to the original data source, and since initial decision making rests with an individual or a small collection of individuals, it risks concentrating power.

3.2. Currency Issuance and Destruction

3.2.1. Issuance

Both Modern Talents and regional currencies will have two main mechanisms of currency issuance[7]:

- Payments to *verified members*.
- Rewards to data providers/miners.

Modern Talents will be issued to any verified human member of a participating region who becomes a talent member and then requests them. The total allotment for each member will be determined once per year utilizing a calculation with an inverse relationship to atmospheric CO_2 equivalent levels; demurrage rates will be determined and updated continuously. Members can elect to receive their allotment in one to twelve payments over the course of the year, at a time of their choosing. Receiving a lump sum allotment immediately will not hold any obvious advantage over receiving a lump sum at the end of the year, or

[7] A third mechanism popular with existing cryptocurrencies, the Initial Coin Offering (ICO), is possible but strongly discouraged. ICOs are often used to finance cryptocurrency projects by selling coins for fiat currencies such as euros or dollars. While an ICO can provide a shortcut to financing development costs, it concentrates the new currency into the hands of those who have the ability to pay for it with fiat money - an outcome that mimics the present state of currency maldistribution, one of the problems that the Talent Network seeks to resolve.

In addition, ICO investors typically have expectations of profiting from their investment. Once invested, they can influence the direction of currency development to match their expectations, and in so doing undermine the equitable distribution of Talent Network currencies.

over receiving twelve equal monthly payments; demurrage will not begin to impact the value of the payment until the currency is created and allocated to a participant[8].

The other global currencies will, initially, be distributed exclusively to data providers/miners.

Regional currencies will primarily be issued as on-demand monthly or twice monthly payments to all verified adult members. Members should be required to request a distribution at every period for which they wish to receive one. Requesting an issuance (or, alternatively, confirming it) can be a simple process initiated from a wallet app or website (such as logging in and clicking a payment request button for a defaulted amount), but manual confirmation from the participant is preferred so that currency is not generated for those who do not intend to use it or whose membership has lapsed.

In order to become a member or a participant in a regional currency, a person must be verified. The verification process will be determined independently by the regional currency developers, but at minimum it must guarantee the uniqueness of every *participant*, so that no single participant receives multiple incomes. Basic incomes should only be available to *members*, who are adults (age 18 or over, typically) and independent minors, so that prolificacy, which is unsustainable in the long term, is not unintentionally rewarded. Regular transaction payments can be made to any validated human participant regardless of age. In the future regions may vote to adopt more stringent currency rules to protect themselves from the environmental harm and resource competition created by overpopulation.

Recurring basic income payments to a verified adult have more components than simply assigning a mining reward to oneself. Mining rewards are easily originated from the miners themselves and require no database lookups. The identity lookup and validation tasks for basic income payments could originate from agents and a database that are separate from the data providers and hence separate from the blockchain; if so, these agents and database must also follow the same replication and verification model that bitcoin does, and the data providers must confirm with multiple agents/databases that the validations are correct. Existing distributed databases such as IPFS, Storj, or BigChainDB may suffice as an identity database solution, or one may need to be developed using the same principles (The Augur Report, 2016).

Alternatively, in a 'magic wallet' scenario, the original identity verification process leads to the creation of a wallet and key pair based on a hash of a member's name and unique identifier (with similarities to an OpenPGP identity certificate (Feisthammel, 2004)) and indicates that he or she is verified to receive basic income payments. This is similar to that member receiving a payment at wallet creation, but instead is a flag indicating that they have been successfully verified, and are eligible for payments. Obviously in this scenario there must not be a way to spoof this information without going through an actual verification. In addition, since identity certificates will not be stored with a third party, a web of trust implementation may be necessary in this case.

Data providing/mining is also a source of currency issuance. Like bitcoin miners, data providers can assign the reward to themselves when their block is confirmed. Rewards should be assigned to individual

[8] A reason that demurrage is preferable to inflation as a means of preventing currency hoarding.

humans who operate a data provider and not to organizations, nor to addresses lacking a clear human owner, and each data provider must be limited to a single node per currency[9]. If governments target data providers in an attempt to disable the network, this policy may need be revisited.

Markets may develop in and among the various Talent Network currencies; initially network currencies should make no effort to set exchange rates or issue currency in exchange for other currency. If results from a trial implementation suggest that fixed exchange rates should be utilized inside the network, this can be revisited.

3.2.2. Destruction

There is no controlled currency retirement or destruction plan for Talent Network currencies. No central organization or decision-making body will purchase issued currency with another currency and then retire the purchased money in order to manipulate trading values or bolster the economy.

The value of all network currencies will be reduced over time through demurrage, so long as the underlying measures show planetary health to be in decline or below boundary levels. This is an implicit form of destruction, as eventually the value of currency issued on a particular date is reduced to a near-zero value.

In the case of participant death, some portion of the currency that that person would have received had they lived longer is not created - an implicit currency retirement. See below.

3.2.3. Participant death

When a participant dies, currency issuance to that person's wallet must stop. Determining when someone has died has the potential to be a challenging task. If relatives stand to benefit by collecting the deceased's payments, they may attempt to utilize the deceased's electronic wallet to request payment, or spend the deceased's existing currency.

There are two possible ways to address the issue of mortality reporting and fraudulent payment collection from a deceased family member:

1. *Life insurance automatically provided to currency participants.* When a participant's death is recorded, a lump-sum amount can be made available to the participant's named beneficiaries, who can then choose when and how they wish to receive it (all at once or in payments). The amount provided in an insurance claim can vary based on the age of the deceased at their death. Death benefits should be great enough to assist the beneficiaries through the loss and encourage honest reporting from the beneficiaries about a death, but not so great as to encourage malicious behavior or cause inflation. A general rule of thumb is that the death benefit should be less than the expected value of the payments left in the participant's expected remaining lifespan given their present age; in the case of a young person, perhaps significantly less.

[9] Restricting data providers/miners to one instance per confirmed human account and publicizing the real identity of the owner of the account reduce the likelihood of Sybil attacks on the currency from data providers. This policy also ensures a greater number of unique data providers and limits the concentration of wealth problem.

2. *Annual renewal of ID verification.* If identification verification is an annual affair and is robust, the longest someone would be able to use the deceased participant's wallet and collect his or her currency payments is one year. This places an upper bound on the potential for fraudulent collections.

A combination of life insurance and ID verification renewal will likely be the best solution for addressing member death.

3.3. Currency Usage (Making and Receiving Payments)

Regional currency template software will be created and used for the trial run. In the template, payments can only be made from and to registered participants in the currency, and only human beings can be registered participants. The template block will include the unique identifiers for each party to a transaction in addition to payment addresses.

To pay or receive payment from any organization (government, corporations, nonprofits, etc.) using this model requires a shift in operating procedures. For example, if someone named Frank wishes to pay an organization, he must instead pay an individual or group of individuals who represent that organization. Then, Frank's payees can distribute that payment further to other members of their organization if they wish. Frank will have the ability to track the subsequent activity of his payees (or anyone else in the network at any time, for that matter) to see how they spend their money and pay others in the network. An option to name a parent transaction (and consequently to be able to show a chain of transactions) will be available, so that Frank's payees can voluntarily provide information that shows Frank how his payment is further distributed after it leaves his account. Some limit on the number of payees per transaction must be enforced in such a system in order to reduce block complexity; if the payee limit is ten individuals, Frank's payment could still be distributed to as many as 10,000 people with as few as four layers, or iterations, of payment distribution.[10]

Whether organizations will accept or refuse to accept regional currency payments from Talent Network currencies is uncertain. Talent Network currencies decouple the three traditional functions of money; while they will function as a medium of exchange and a unit of account, because of demurrage they are not exactly a long-term store of value. Therefore we should expect other currencies with other aims to exist as contemporaries of Talent Network currencies. If organizational leaders have a choice, they may

[10] This approach may seem confusing to those of us accustomed to dealing with large organizations every day of our lives. Why should we throw away the apparently useful shortcut of naming an organization rather than individuals? And, won't most organizations refuse to adapt their procedures in order to accept such payments?

The answer to the first question rests in the fact that organizations may be useful, but they are useful fictions. Organizations are collections of individuals; while they may have cultures and principles of their own that define the behavior of their members, they are not independent human beings. Once organizations are treated as entities that can independently accumulate capital, the path is short to their acquiring 'personhood' and dominating the political landscape, a problem that now plagues the US political system and others. In addition, a monetary system in which all transactions are public can only work when everyone is exposed equally; if anyone is permitted to hide behind the label of an organization name, trust in the system can break down.

refuse to recognize or distribute payments from network currencies that require all payments be made to organizational members and do not allow direct payments to the organization. Governments, for instance, are unlikely to accept payment of taxes directly in a Talent Network currency without some struggle, since taxes are a primary means of legitimizing their fiat currencies and their consolidated power.

An initial objective of the Modern Talent and the Talent Network is to provide an alternative to entrenched cultural patterns, which then has the potential to shift the focus of people's attentions. In a regime of greater awareness of the problems that humanity both faces and is causing, conventional wisdom can shift, encouraging widespread adoption of Talent Network currencies, and forcing firms and organizations to accept payment in regional currencies and Modern Talents.

Nevertheless, regions are free to decide how to design their own payment criteria and will not be required to follow the template's model of restricting participants to humans (though every transaction must still have a single human identified as the originator or responsible party). So long as the regional currency at least fulfills the criteria necessary to link it to the global currencies and measures, it will be considered a legitimate Talent Network participant.

3.4. Demurrage: Purpose, Calculation, and Implementation

In currencies, demurrage means a charge on holding money. The term was first used to describe a charge on money by Silvio Gesell, an economic theorist of the late nineteenth and early twentieth century (1958). Demurrage stands in contrast with interest-bearing money, which gives the holder the ability to accumulate more wealth simply by already possessing it. When a currency has demurrage, it loses value over time.

There are similarities between demurrage and inflation, but inflation typically occurs when the total money supply increases, and for the holder of the currency, usually the specifics of the inflation are somewhat opaque and only known after it has occurred. In a system that has demurrage, the actual notes issued lose value over time according to the demurrage rate. In historical examples of currency demurrage, it was implemented with a system of stamps that had to be purchased and stuck to the notes ('stamp scrip') as they aged in order for them to be used (Douthwaite, 2000). In the purely digital world of the Talent Network, it is relatively easy to continuously subtract value from all outstanding currency as it ages.

Demurrage has several purposes:

- It increases the velocity of money by discouraging hoarding (Douthwaite, 2000).
- It limits wealth accumulation solely through holding currency.
- It upends conventional 'time value of money' concepts and Net Present Value calculations that underlie the common expectation that loans will earn interest for the lender, allowing those who hold sufficient capital to live luxuriously without effort and amass further wealth.

The demurrage rate calculation for each of Modern Talents and regional currencies should be implemented as a curve - i.e., a continuous nonlinear function - rather than as a simple linear function or an equivalence of observed rates of decline of any measure or measures.

For instance, if atmospheric CO_2 equivalent levels are observed to have increased by 1% over the past year, it does *not* directly follow that the demurrage rate for the Modern Talent should be 1%.

This is because most of the measures have associated planetary boundaries, which represent threshold levels beyond which abrupt changes can occur (Rockström, et al., 2009). Once a boundary is crossed for a measure[11], sudden or potentially runaway effects may be expected. If we denote the demurrage rate function as *f(demur)*, then:

$$f(demur)_{measure\ x} = f(annual\ change_{measure\ x}\ ,\ boundary\ level_{measure\ x})$$

So, an appropriate demurrage rate function for a particular measure must incorporate the available evidence on what nonlinear change to planetary health is likely as a result of an annual percentage change in a measure, along with any boundary level[12].

In addition, the demurrage rate of a currency affects human behavior and attitudes, and this must also be taken into account when assigning a rate function to a measure. To address this, demurrage rate curves for currencies distributed as basic income should have the ability to shift through democratic influence.

FInally, the demurrage rate functions must at all times be completely transparent, and any possible shifts to a demurrage equation must be planned and published far in advance.

Demurrage rate functions for global currencies which are not distributed as basic income need not have a democratic component. The process for determining an initial function will be the same as for talents and regional currencies - the point being to most accurately approximate the true decay in the component being measured.

3.4.1. The importance of measurement accuracy for demurrage calculations

All metrics must be capable of being measured with a sufficient degree of accuracy using current technology in order for them to be used in currency calculations. ‘Sufficient’ in this case means that the margin of error (MOE) in observations for each measure must be a relatively small percentage of the year-to-year changes or Δmeasure (unless the annual change is negligible); otherwise, the validity of demurrage rate calculations for that measure would fall into question.

If the MOE/Δmeasure test fails for any measure, it suggests that that measure cannot be accurately demurred using annual changes. In such cases the rate of change calculation can be expanded to incorporate a greater number of years, until the margin of error is satisfactorily exceeded. The resulting value can then be annualized to provide input to a demurrage rate calculation. For example:

[11] For some of the measures, the boundary levels have already been crossed, and nonlinear transitions to new equilibrium states are likely underway.

[12] Who determines the exact equations for the initial condition demurrage rate functions, and what strategy they use to determine them are not yet precisely known.

> Assume today is May 31, 2019. The measured annual rate of change in the N metric (ΔN) is 1.3% growth in anthropogenic nitrogen fixation. Assume also that the MOE in the May 31, 2018 calculation of the total anthropogenic nitrogen fixation is 1.3%, and the MOE in today's 2019 calculation is 1.2%. We could not safely calculate an accurate demurrage rate based solely on ΔN for the past year, as the average MOE in the measurements is 1.25%, which is 96% of the 1.3% growth figure. We would need to incorporate figures from other years into the calculation to reduce the impact of the MOE.[13]

The drawback of this approach is that current changes will have little impact on the measure and hence on the demurrage rate. Thus improving the accuracy of the measure is critical to creating a currency that responds quickly to changes in the environmental measure that underlies it.

3.5. Democratic Influence on Currencies

All rules and calculations concerning the amount of currency issued to each participant as well as demurrage rate curves will always remain completely transparent and based on measures. This is true for all Talent Network currencies. Any modifications to standing rules that directly affect currency value or demurrage rate function equations will be subject to a vote of all verified members, rather than being controlled by developers, data providers, or any leader or group.

Regional currency members must also collectively decide on such things as:

- Any measures that will be in the currency basket that are not part of the original template and are not required by the Talent Network.
- The relative weights of the measures that comprise the currency basket. These weightings must be freely available and public information.
- The elements comprising each of the complex measures, and the weightings of each element in calculating the overall measure.

Once established, only through a democratic vote of all participants can these rules change.

Implementing a voting mechanism for the currencies is an additional challenge. Augur and Gnosis[14], cryptocurrency assets that are both implemented as sidechains to Ethereum[15] and allow people to bet on future outcomes,[16] could be used as a model for developing a voting platform for the Talent Network currencies. Augur uses a network of reporters to establish the actual outcome of the predicted event - this is a type of voting system (Bitcoin Uncensored, 2015).

[13] What is an acceptable ratio for MOE/Δmeasure? That question is best left to regional currency participants to answer.
[14] The co-founder of Gnosis has his own project for implementing UBI through cryptocurrency, which he has named 'Circles' (Köppelmann, M., 2015)(Köppelmann, M. et al.)
[15] Through the use of Ethereum 'smart contracts', which allow the execution of code in the sidechain.
[16] Termed 'prediction markets', or in essence a form of gambling.

4. Implementation Challenges

4.1. Participant identification and verification

The exact mechanisms for identity confirmation and age verification are unknown. How will a person confirm to a regional currency network that they are who they claim and that they are of valid age, without resorting to official government IDs or documents, and trusting a third party to confirm this? While a fingerprint or DNA sample may uniquely identify someone, neither confirms a person's age or legal name. And, if a fingerprint is taken, who records it and confirms the identity of the person to whom it is attached, and where is it then stored? The fingerprints can either be a prerequisite for obtaining a key pair or for being entered into a database; but in the case of a key pair, it must somehow only be capable of being generated based on a confirmed identity, and this process must be incapable of being spoofed. In the case of the database, it adds an additional layer of complexity.

A web of trust could be utilized to confirm that a person's public key matches their identity (Feisthammel, 2004), and that they are age verified. In such a system, that web determines who will be willing to interact with whom, based on the contents of their key ring. If one user verifies another, and then that user is trusted by a third, the third user may trust the first. The drawback of this method is that it reduces the fungibility of currency in the Talent Network: i.e., not all currency will be valued equally by everyone, and it instead depends on who holds it. This is a serious issue that could hinder broad acceptance of a currency, so we should avoid this solution if at all possible.

Distributing currency only to confirmed members and restricting currency transactions to confirmed participants are similarly difficult. They both also require one of the two additional elements mentioned above:

- *A quickly searchable database of all confirmed members and participants for each currency, which would include ID numbers, names, their public keys, and their most recent basic income payment*. In this case, the data providers would be required to confirm every payor and payee of every transaction when adding it to a block, and every confirming data provider would have to confirm every payor and payee of that block. The database would have to be replicated through a peer-to-peer trustless network much like bitcoin, with those running database instances receiving rewards for storing and retrieving confirmed identification records.
- *A database-free system in which a member's validated, unique identity is incorporated into their wallet and key pair*. In this case, only validated members can receive a wallet and key pair, and their software identity must incorporate a unique identifier of the member that cannot be spoofed, and perhaps must incorporate a web of trust component. It must also not be possible to generate a false identity outside the network and then request payment. The blockchain software must keep track of a particular member's currency requests and have the capability to deny requests that arrive early, or, it must have the ability to post a tentative payment, which the payee must confirm before a transaction can become a genuine ledger entry.

Neither of the above solutions is elegant or complete. Input from cryptography experts and those familiar with the problem should lead to better designs and solutions.

4.2. Fully public nature of currencies untested

An important feature of the Talent Network currencies is that they will be completely public, with the real identities of human participants as well as all of their transactions available for anyone to query. Data providers will be associated with a human as well, with no single person allowed more than one data provider node.

Making a digital currency completely public flies in the face of conventional wisdom. Most cryptocurrencies seek to divorce online identities from real-world ones, and in some cases, aim for a goal of complete privacy, like Monero (The Monero Project, 2017). One of the stated aims of these projects is to protect people from unwarranted monitoring and retribution from governments or attacks by identity thieves or anyone with malicious intent. If powerful entities get this information, the reasoning goes, it can lead to 'Big Brother' situations in which these entities can monitor everyone's every move, manipulate people based on their habits, and curtail personal freedoms.

Another potential drawback of making a currency fully public is that fungibility could be compromised. This is certainly true if a web of trust is implemented to assist with identity validation, but it is also true based strictly on knowing identities and payment history. If a known criminal pays someone who then attempts to pay someone else, even though the blockchain will not reveal what was purchased in that transaction, will the second payee demand an amount greater than standard payment because of the payor's associations? If so, is fungibility truly compromised? There is, as of yet, no clear answer. Only a trial implementation can provide definitive insight into the likelihood, as well as shedding light on the implications.

The logic of these arguments for private currencies and against public ones appears sound. Why, then, make the Talent Network currencies public?

First, there are technical reasons for doing so. If the currencies are peer-to-peer and all adults are eligible for basic income payments, there must be some way to identify who is an adult human and prevent any individual from collecting multiple times. If this validation and identification process is done in such a way as to centrally store and 'protect' that information from prying eyes and identity thieves, this compromises the principles of the currencies because it is a centrally controlled repository. Furthermore, the implication is that the data will be safe, leading people to believe that they can conduct themselves as if it is. Nothing, however, could be further from the truth. Think Equifax, the US government, Apple, Seagate, Wells Fargo and other banks, and myriad other organizations whose private data on people has been manipulated, stolen, or revealed. Any system with a repository of personally identifiable information can be compromised, and when it is, it will assuredly be in malicious hands.

Second, by forcing *everyone* participating in the currencies to identify themselves, the Talent Network aims to level the playing field. No one should have the ability to hide behind faceless bureaucracies while those with less power are exposed, so the Talent Network expressly prohibits it. As Charles Eisenstein says in *Sacred Economics*, "When the activities of government are just as transparent to the people as the activities of the people are to the government, we will have a truly open society." (2011, p. 151)

Finally, there is precedent for creating fully public economies in ancient and traditional societies (Mauss, 2002), and the evidence suggests that it is more in line with the better aspects of human nature. Eisenstein again:

> Many people would find the idea of no financial privacy very threatening. Since money today is so bound up with self, we would feel exposed, vulnerable—as indeed, in today's society, we would be: exposed to envy and judgment and vulnerable to criminal extortion and demands from importunate relatives. In a different context, though, financial transparency is part of a way of being that is open, trusting, unguarded, and generous—being a person who has nothing to fear, who is comfortable in society. (2011, p. 299)

As acceptance reaches a critical mass, this approach can radically change the way business is conducted among people. Until that point, however, there is an admitted imbalance: organizations don't have to conform to the rules if they don't accept the currency, but they can still snoop on the behavior of participants. So, moving forward until critical mass is reached requires an act of faith, like stepping into the unknown.

4.3. Confirming measurement validity, uniqueness, and value

Some data providers or groups of data providers may attempt to sabotage a currency by flooding it with bogus or useless measurements. The owners of these nodes may be politically or culturally motivated to do this and see themselves as morally righteous. Because they are not motivated by wealth, their attacks could persist even at great expense to themselves.

This problem is partly addressed by the requirements that data providers use their real identity, not control more than one node, and be subject to timeouts after submitting a block and measurement. However, it will still likely exist. It is imperative that the detailed rules governing measurement confirmation address this potential.

While addressing the validity of a measurement is discussed in an example in this proposal, uniqueness and value are not, beyond the requirement for a data provider timeout. How exactly the system will determine what constitutes 'uniqueness'[17] and 'value'[18] has yet to be determined. The final determination could add complexity to the design, or it could risk oversimplification and inaccuracy, which could compromise trust in the measures. It should be developed carefully.

[17] Uniqueness can imply more than simply that a measurement at this location and time has not previously been submitted, but instead can indicate data quality given the existing dataset.

[18] Value is a fuzzy principle that can change as the dataset changes; for instance, if measurements from some locations are needed more than others in order to provide a balanced sampling, those measurements will at that time be considered more valuable.

4.4. Scaling

Present cryptocurrencies such as bitcoin have very serious scaling issues. In part this is because of the worldwide computational power devoted to computing the solution to cryptographic hashes in order to add a block to the blockchain (Malmo, 2015). Computing a hash (a form of computationally taxing puzzle that is, in essence, artificial work) is required in order to add a group of payment transactions, or block, to the ledger, or blockchain, and prevents any one entity from controlling the ledger and breaking the trust in the system. Each hash solution is dependent on the contents of the block, and the block's content is dependent on the prior block's hash solution; thus there is a great deal of computational work embedded in the blockchain that cannot easily be recreated by someone attempting to fake the blockchain for their own ends (Nakamoto, 2008). Adding hash puzzles as a requirement to add a block to the blockchain (and rewarding 'miners' by making payment in the coins for doing the work of solving the hashes) was a major breakthrough in resolving the double-spend problem inherent in a distributed ledger, and so cleared the way for creating a true peer-to-peer currency. If a miner were to attempt to modify the blockchain in order to spend some coins twice, he would have to perform a tremendous amount of computational work, negating the benefit to him in doing so (Nakamoto, 2008).

Unfortunately, the miners' efforts to solve bitcoin hashes consume an enormous amount of electricity worldwide, and this is of great and grave environmental consequence (Deetman, 2017). The Talent Network currencies must employ a less environmentally expensive method to add a block to the blockchain in a trusted manner if the network is to succeed at scale without substantially harming the planet and people it endeavors to protect.

As discussed in the explanation of the push strategy, in the Talent Network currencies every block must contain unique, validated, and valuable measurement data - and calculated measure value and demurrage rate information - in addition to the transactions. This additional requirement over that of simple mining of hashes, along with a restriction of one data provider to one human, reduces the likelihood of Sybil attacks. Whether mining of hashes can be completely eliminated is not yet known; but at the minimum we can safely conclude that mining complexity can be significantly lower than that for bitcoin.

Lessons from the Ethereum implementation, which has a more complex blockchain than bitcoin and hashes the system state with every block, may be applied in implementing Talent Network currencies. In order to limit the growth of the blockchain, dead nodes from the Merkle trees in Ethereum can be pruned - similar to a compression algorithm that eliminates redundant data (Buterin, 2015). This reduces the overall growth of the Ethereum blockchain from $O(n*log(n))$ to $O(n)$, roughly. If nonlinear blockchain growth becomes a concern in the Talent Network, this compression pruning should take place as soon as the block's depth in the blockchain is adequate.

More generally, the growth of the blockchain in the Talent Network currencies, and especially in the Modern Talent, must be limited as much as possible, and when transactions are kept, should be $O(n)$. In other words the blockchain should only grow linearly with the number of transactions.

Even so, the blockchain data requirements for a fully operational, worldwide Modern Talent currency are tremendous. If transactions average 500 bytes each, and there are 200 million transactions per day, 100

GB per day will be generated in transaction information alone. At one billion transactions per day, there would be 500 GB. Clearly at these scales the complete blockchain cannot reasonably reside on a data provider's compute-focused hardware or personal PC, at least not without purchasing a prohibitively expensive storage array. A top-of-the-line[19] 16 TB SSD would fill in less than half a year in the low-volume case; in the high-volume case, it would be full in just 32 days.

Perhaps more concerning, passing this volume of data over the internet as new data providers seek to join would be impossible at today's bandwidths. Not calculating overhead and resends, sending 100 TB of data over a 1 Gbit ethernet connection would take 222 hours, or over 9 days; over a 20 Mbps internet connection, 463 days.

Therefore, the entire blockchain of the talent cannot reside with data providers. If it is to persist, it must be offloaded to some form of replicated, distributed data warehouse - a *block warehouse*. The 'offloading' need not be an actual offloading exercise; instead, the block warehouse can be a different type of node in the network that never attempts to contribute or validate a block, and instead only stores blocks that have been confirmed, i.e., those that have reached a particular block depth in the blockchain and are unlikely to be double-spent. This is a storage-focused node, and the owner of this node should be rewarded differently from a data provider/miner. The block warehouse node owner should receive an award when the node provides a correct query result that is in agreement with other block warehouse nodes, and matches the block header data that remains on the data provider's blockchains.

The data providers will retain block header data but purge transactions from the block Merkle trees once the data has aged a certain number of blocks - specifically, long enough to prevent any double spends and longer blockchains from arising. This will allow data providers to confirm the validity of a block and that a particular transaction was part of it through the Merkle tree root hash in the header, but they will not be able to retrieve the actual transaction[20]. The actual transaction retrieval must be a query to the block warehouse. If the data is reduced by a factor of 10,000 (the exact reduction depends on the block size and the block header size), and one day of complete data is retained on the data providers' blockchains, and only block header data for blocks older than 24 hours, for a billion transactions daily, one year of data would be equivalent to:

$$500 \text{ GB} + 364 * (500 \text{ GB} / 10{,}000) = 500 + 18 = 518 \text{ GB (approx.)}$$

This is a far more manageable amount than hundreds of terabytes or petabytes, but it still would be prohibitively slow to transfer this amount of data to new data providers. Reducing the volume of transactions stored by the data providers to less than a day would reduce the size further, but could complicate matters beyond a certain point if there were any slow transaction confirmations. How little transaction data can be stored with the data providers without risking attack or error is presently unknown.

[19] As of September 2017.
[20] This is essentially a modified SPV (Simplified Payment Verification) node (Antonopoulos, 2017)(Nakamoto, 2008).

An additional problem is that the block warehouses have a restriction that data providers/miners do not have. There must be an adequate number of block warehouse nodes in existence to ensure data persistence before any data can be purged from data providers' blockchains. Once data is purged from the data providers, a critical dependency on the block warehouse nodes is created; unfortunately, new block warehouse instances cannot be easily created from that point forward, because of the data transfer time combined with the extremely high ongoing transaction throughput.

In addition to the data storage issues, the incredible volume of block validations being requested and confirmed could become problematic. If so, it may be necessary to partition the Modern Talent into multiple *blockchain pools*[21], either through regional assignments, groupings of participants who frequently interact, or, new participants could be added to new pools once a threshold is reached and existing pools are saturated. Every pool would have a separate but interconnected blockchain.

Each verified participant would then have a *home pool* - a default - in which they had a *home address*. It is in a member's home address that he or she would receive basic income payments.

In addition to having a home address, all verified participants would also receive addresses in all other pools; these are their *visitor addresses*.

Data providers (who, recall, are linked to a human and restricted to a single node instance) would work only within their home pool. Communication points would be necessary among the pools to interlink the independent blockchains through hashing and to exchange information about measure data and demurrage rates.

Any participant could easily be a payee in any of the pools. However, the difficulty arises when a payor wishes to pay someone in a pool where her balance, or unspent transaction output (UTXO), is zero even though she has a positive home pool balance; or, when she wishes to transfer payments from one of her visitor addresses to her home address.

This situation could be handled one of two ways:

- *Outside the scope of the Modern Talent infrastructure, through independent market*s. This is the easiest solution. However, this creates an unwanted opportunity for scalping, in which market makers profit from what should be 1:1 transfers. In addition, market dynamics could skew values in such a way that a talent in one pool is worth less than a talent in another pool - an undesirable outcome.
- *Through a special 'interpool intraparty' transfer*. This would be a special type of transaction only permitted from one of a verified participant's addresses to another (which would have to be linked to the participant using our previously discussed distributed, replicated database of verified participants). This special transaction type can be thought of as similar to a bank wire; at a participant's request, some amount of talents is destroyed in one pool; then, once confirmed, the destroyed amount is created in the other pool, at the participant's address there. The complete

[21] Not to be confused with bitcoin mining pools.

chain for that currency token now crosses blockchains, adding complexity. While enabling interpool interparty transfers is better for participants, whether this method can be implemented practically without either compromising trust or hobbling the system with cross-blockchain queries for transactions is not yet known.

Some combination of block warehousing and blockchain pools may be necessary to support full scale transaction volumes for Modern Talents, and possibly for some other network currencies as well.

Finally, the blocks and the blocksize must also be designed to permit adequate scaling.

4.5. Gaming and Manipulation of the System

There is a very real potential for whole regions to attempt to manipulate or fabricate data in order to attempt to 'game' the system, and in so doing, invalidate an entire currency and risk rejection from the Talent Network[22]. Regions could also attempt to break the spirit of the regional currency rules by limiting the required measures to a tiny fraction of the overall currency weighting, while adding measures that have nothing to do with planetary and human health but instead promote extraction and destruction.

It must be clear to all developers and participants that regional currency code must conform to the basic rule set described in this document, and that a failure to follow that rule set will be grounds for removal from the network, thereby stopping those regional members from receiving any new Modern Talents. There must also be a decentralized decision-making process for determining if a region is conformant or not when a question is raised. This decision-making process could function similar to Augur's reporter network, which confirms the validity of an event using reporters who have more influence the more trust they have accumulated (The Augur Report, 2016).

A rejected regional currency should be able to quickly re-enter the Network once developers have implemented the elements necessary to make the currency conformant - another distributed decision.

The temptation for one person to attempt to create multiple identities and receive payment from all of them will be present as well. The yet-to-be-identified mechanism(s) for identity validation must be very robust.

4.6. Other Potential Challenges

Briefly, other potential challenges with the Talent Network project include:

- *Project complexity*. At full scale, this is a very large and complex effort. It is within the technical capabilities of present-day computing to implement the Talent Network worldwide within a reasonable timeframe, but it requires a dedicated and talented group of people working on the project, and broad interest and support.

[22] I personally believe this mindset is confusion that arises from being indoctrinated into the present economic system, in which a tiny minority of people benefit at the expense of the vast majority, and at the expense of the environment. The ultimate reward for cheating is self-destruction, though in a system like the present one, some may live out their lives in luxury while never experiencing this cost.

- *Finding developers who believe in the project and will contribute without expectation of becoming personally wealthy from their efforts*.
- *Decision-making process for resolving code issues and setting initial conditions*. A non-hierarchical method for quickly addressing code issues and providing initial formulas for demurrage rates and measure value calculations is necessary. The details of demurrage rate calculations for both global and regional currencies were intentionally omitted from this paper. Initial-condition demurrage rate equations should be decided on once people who have greater knowledge of the data and the relevant Earth systems become involved in the project.
- *General interest, adoption, and acceptance*. For Talent Network currencies to be broadly useful and support people's livelihoods, a critical mass of adoption must be achieved, and the idea must be accepted as valid and valuable.
- *The concepts of land ownership and mineral rights*. The Talent Network currencies cannot, by themselves, rectify the present wealth inequality in the world. Legal structures in place enforce that inequality in ways that extend beyond currency.
- *Government hostility*.
- *Dismissive or hostile reception from corporations and the wealthy*.
- *Taxes collected in fiat (bank-created) currencies*.

5. Next Steps

Design and development of the code elements necessary for a trial implementation can proceed after further vetting of this proposal. The design should incorporate feedback from interested and knowledgeable parties, and do so without compromising the project objectives. Where possible the lessons of bitcoin, Ethereum, and cryptocurrency assets such as Augur and Gnosis should be applied and suitable design elements from these projects included in Talent Network currency design.

The broad steps in a development effort are:

1. Assemble team, agree on standards.
2. Develop specifications and code for a single non-UBI global currency.
3. Proceed with trial implementation of non-UBI global currency.
4. Develop specifications and code for a template regional currency.
5. Develop specifications and code for the Modern Talent, either with or without pool capability.
6. Proceed with complete trial implementation of a single region using the region template plus the Modern Talent.

6. Conclusion

I have proposed a network of digital currencies - the Talent Network - with regional currencies, global currencies, measures, and a global reserve, the Modern Talent. The currencies establish a principle of measurement of global and regional life-supporting commons for the purpose of establishing currency values and demurrage rates based on the health of those commons. It is from this commons that all human endeavors and livelihood arise and proceed. Regional currencies will be distributed as basic income to adults, and talents as reserve income. All currencies will have a public transaction infrastructure that dissuades bureaucratic hiding.

This is a complex and ambitious project. Many aspects of it are left unresolved here, which I have indicated where possible. Some solutions must wait until a trial implementation, through which the behavior of participants and the system can be better understood.

My expertise is broad but not necessarily deep. I am not a cryptography expert, and all errors herein are mine. With involvement from those who have more focused expertise, the components described in this paper will surely evolve and the mistakes be corrected as the project proceeds.

I wholeheartedly welcome involvement and dialogue with those:

- who feel inspired by the possibilities alluded to in this paper - that creating a new model for currency can shift mindsets as well as economic practices;
- with ideas of how to design a cryptocurrency network that serves all people and recognizes our obligation to safeguard the one planet that we know we can live on;
- and with those with greater knowledge and skill than I in the areas where I have stumbled or where my thinking is incorrect or incomplete.

Ultimately, we live on a beautiful and priceless planet. It is our home. There is a danger in the act of measuring and quantifying, which is that we lose ourselves in thinking, our brains filled with amounts and rates and schemes. But we must not disconnect from the source of our wisdom - our hearts - if we hope to leave a habitable world to our descendents.

It is my heartfelt desire that this proposal be taken in the spirit in which it is offered - a starting point, and a gift.

* * *

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