The Next Generation Humanitarian Distributed Platform

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About This Report

This report is the result of a collaboration between the Danish Red Cross, Mercy Corps and hiveonline.

Research Basis for the Next Generation Humanitarian Distributed Platform Report

The research for this report is compiled from responses of 35 survey participants representing key stakeholders in the humanitarian sector, including NGO project implementers, consultants, blockchain developers, academics, and founders. A further 39 direct interviews took place over the course of the research between July and September 2020 (See Appendix 1). Based on this engagement the report takes a deep dive into humanitarian blockchain project implementations to date and explores the potential for an early collaborative, cross-agency effort for the design, development, and build of a unique blockchain/DLT tailored to support the unique needs and values of the humanitarian sector.

The report consists of two sections:

Part 1)

Blockchain and the humanitarian sector: The first provides an overview of distributed ledger technologies (DLTs) and blockchain and will further explore how the technology has been adopted by first movers in the humanitarian sector: illustrated with use cases and project examples. The section also explores the challenges and opportunities found in both the technology itself and in the implementation thereof.

Part 2)

A distributed ledger for the humanitarian sector: The second section provides an overview of key components and factors to be considered for the design and implementation (or adoption) of a humanitarian DLT, such as governance, business model, and consensus.

Finally, the report concludes with the authors' recommendations based on research findings.

Editorial Team and Contributors

Authors: Sofie Blakstad and Charlotte Melkun (hiveonline), Ric Shreves (Mercy Corps)

Contributors: Dr Jane Thomasen (Fintech.tv), Fritz Henglein (University of Copenhagen / Deon Digital)

Expert Review: Rob Allen (Blockchain Technology Adviser), Adam Bornstein (Danish Red Cross)

Editorial: Nick Moody

Graphics and Layout: Charlotte Melkun, Becky Shapiro and Sofie Blakstad (hiveonline), Caroline Lucas and Betsy Krueckeberg

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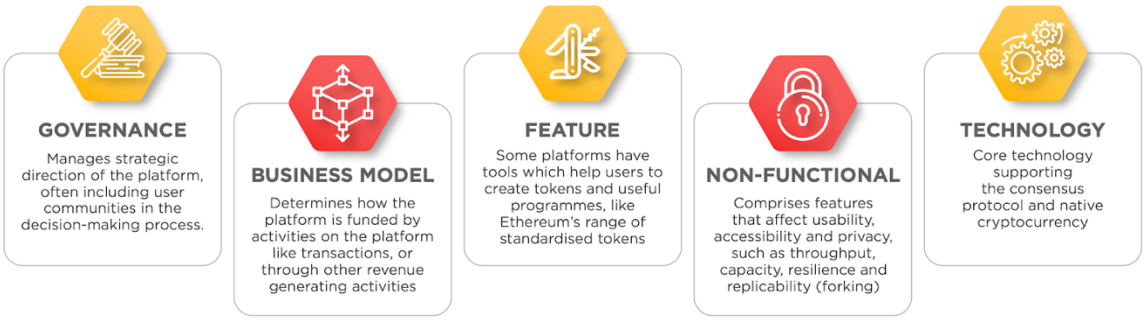
1. Executive Summary

This paper describes the current standing of blockchain and (more broadly) Distributed Ledger Technology (DLT) in the humanitarian sector and looks at the opportunity the technology could bring. It shows how international relief and development actors, including Non-Governmental Organizations (NGOs), and Civil Society Organizations (CSOs) can deliver increased benefit to the vulnerable people they support through creating a more efficient, trusted and collaborative humanitarian system.

Those unfamiliar with the technology may be surprised to know that DLT has already been tested or partially adopted by a number of international relief and development agencies[1]. The research on which this paper is based investigated the experience of people working with blockchain in international NGOs, CSOs and the private sector firms supporting them. The consensus among these stakeholders[2] is that effective use of the technology could deliver improved humanitarian outcomes and support the evolution of the sector. The paper presents the following recommendations:

- Establishment of a working group with representation from key stakeholders to progress the design and development of an open DLT platform specific to the needs and values of the humanitarian sector
- Creation of a holistic structure to support the platform including the following DLT Structure Layers:

Figure 1: DLT Structure Layers



In summary, a distributed ledger for the aid and development sector should be easy to use, providing accessible and appropriate tools. Unlike some DLT solutions it would be low cost and low energy, and unattractive to speculators. It should have a sustainable business model and be governed in a collaborative way that operates and evolves the platform based on the needs of the communities it supports.

The international relief and development sector must continue in its efforts to become more efficient[3]. The Humanitarian Grand Bargain[4], signed by most major NGOs, promotes transparency, collaboration, reduced

[1] Examples include WFP Building Blocks, Oxfam Unblocked Cash, World Vision Sikka, Red Cross Red Crescent/Grassroots Economics CIC.
[2] Based on interviews and surveys conducted for this paper, see Appendix 1 for details of respondents.
[3] MaxImpact Blog, "What Challenges Do NGOs Face and What Are the Solutions?"; Greenfield IV, "How COVID-19 Is Forcing NGOs & Governments to Modernize."
[4] https://interagencystandingcommittee.org/grand-bargain

duplication and increased cash-based programming for the humanitarian sector. Blockchain and other DLTs have the potential to support these goals. Seeing this potential, the humanitarian sector has been experimenting with the technology for several years. Early projects, which have been ringfenced by necessity because of their experimental nature, have achieved demonstrable benefits in the form of cost savings, transparency, and speed of distribution. They could not, however, demonstrate the full potential of DLT as they encountered challenges related to scalability, cost, lack of collaboration and limited user adoption.

Despite these challenges, there is broad agreement by the stakeholders interviewed for this report that DLT offers many positive and, in some cases, transformative opportunities. The technology offers new avenues for achieving transparency, trust, movement of data or value and creation of tamper-proof records, bringing efficiency and effectiveness to the protection of vulnerable people.

> THE SECTOR RUNS THE RISK OF MISSING THE BIGGER PICTURE OPPORTUNITY, THAT IS, THE ABILITY TO SHARE DATA, REDUCE THE BURDEN OF REGULATORY OVERSIGHT AND AUDIT, AND IMPROVE OUR VIEW OF BENEFICIARIES
>
> RIC SHREVES, MERCY CORPS

Distributed technologies are, by definition, exercises in collaboration that can benefit from network effects. To realise the technology's potential, there is a need for greater collaboration and a common approach across the sector. Early humanitarian implementations started with small scale pilots then transitioned to some wider scale interventions. In parallel with traditional humanitarian stakeholders, new "Blockchain for Good" actors have emerged including independent projects utilizing blockchain for social, environmental, or humanitarian impact. Similarly, there has been a growth in the number of for-profit social impact enterprises with commitments to the Sustainable Development Goals[5] and the Paris Agreement[6]. These non-traditional social impact actors often face the same challenges as the humanitarian sector when using blockchain or DLT platforms.

Our research identifies the need for a common approach to underpin collaboration across the sector.

Towards Collaboration on Common Solutions

The momentum behind a Humanitarian Distributed Platform has been building since the spring of 2017 when Mercy Corps published a white paper entitled "A Revolution in Trust"[7]. The paper included a call to action for the humanitarian sector to examine how a shared distributed ledger could advance and amplify collective efforts and stakeholder collaboration.

Building on the white paper, Mercy Corps in partnership with NetHope and The International Civil Society Centre took steps to build momentum and agreement around the concept, resulting in the March 2019 Blockchain for Social Impact Conference in New York City. While the conference confirmed an interest exploring collaborative

[5] https://sdgs.un.org/goals

[6] As DLT becomes more mainstream, there has been a parallel growth in impact startups based on greater public awareness of social and environmental issues. In 2019 a number of blockchain startups supporting SDGs moved out of the lab, following in the footsteps of now-established pioneers such as BitPesa, BanQu and Provenance.

[7] Mercy Corps, "A Revolution in Trust."

solutions for the application of blockchain/DLT in aid and development, stakeholders were not able to establish a clear roadmap for further engagement and the initiative was tabled.

Mercy Corps is not alone in advocating a shared approach to the development of a humanitarian DLT. The sentiment has been echoed by the United Nations World Food Programme (WFP) which led to the implementation of perhaps the best known humanitarian DLT project to date: Building Blocks. Originally piloted in Pakistan, the program then expanded to over 100,000 aid recipients in Syrian refugee camps, and most recently, to an additional 46,000 people in Bangladesh. On their official website, WFP further calls on the sector to develop a common platform:

"WFP is inviting other UN agencies and humanitarian actors to collaborate on a neutral blockchain network to improve cooperation, reduce fragmentation, bolster efficiency—and ultimately further empower the people we serve" -- WFP, Building Blocks[8]

The Red Cross and Red Crescent Movement (Red Cross) has also joined the discussion around the development of a shared platform for the sector. Following implementation of several blockchain projects including the Community Inclusion Currencies program co-developed with Grassroots Economics and the launch of the Volcano Catastrophe Bond they also identified the need and importance of developing a collaborative, cross agency approach to a humanitarian DLT.

[8] https://innovation.wfp.org/project/building-blocks

PART I

BLOCKCHAIN AND THE HUMANITARIAN SECTOR

2. Why Now?

Distributed ledger technology is evolving rapidly. In the course of the last decade we've moved from early blockchains which were slow, sometimes expensive and carried with them a high environmental impact, to lower-cost, higher-throughput technologies that deliver many of the benefits of early blockchains without the downsides.

Despite the progress, there remain several barriers to using the technology effectively in the humanitarian sector. Some of these barriers are associated with structural challenges in the way humanitarian projects are organised and funded while others have had to do with limitations of the DLT platform selected. Others are associated with the experimental nature of early projects, the caution of organisations when using new technology, structure of donor funding for cross-agency technological innovation and the need to develop or acquire new capabilities.

Based on the learnings from early pilots in cash and voucher distribution (CVA) as well as examination of private sector DLT projects in areas such as supply chain management and identity services, it is clear that opportunities can be realised by the use of DLT. However, to realize the full benefits of the technology, collaboration is required for building a cross-agency approach.

It is a time of digital transformation, stimulated in no small part by the realities of the CoViD-19 crisis and growing need around the world. International relief and development actors are facing a set of common problems and opportunities for which this technology is well-suited to address, including:

- Changing donor expectations regarding both transparency and efficiency
- Increasing needs for data security, portability and interoperability
- Escalating costs around M&E and audit

In this paper, we advocate for humanitarian organizations to come together to rekindle the discussion - to find or build a DLT that fits the need of the sector. The transparency, speed, and savings inherent to the use of DLT can bring great benefits for the recipients of humanitarian aid, yet they can not be realized without a distributed, collaborative approach. It's time for humanitarian agencies to come together, think big, and act to create a solution that benefits agencies, donors, and recipients alike.

This paper and its recommendations are intended to be the starting point for a larger debate around the design, governance, and development of a distributed ledger for humanitarian stakeholders.

3. Why DLT for Humanitarian Use Cases?

Humanitarian actors typically work in an environment that is resource stretched. As non-profits, relying for the most part on donors for financial support, most humanitarian agencies struggle to invest in technology infrastructure, and once invested, tend to hang on to those systems for long

periods of time. As a result, the enterprise technology that powers most aid agencies tends to change slowly and is rarely state of the art[9].

What is Blockchain?

There exist numerous tutorials on blockchain and distributed ledger technology (DLT). Rather than dive into a technical discussion here, we thought it better to focus on why the technology is important, rather than the details of how it works. **While it is easy to become baffled by the new terminologies associated with DLT it is worth bearing in mind the basic principle: it is a potentially universal means of ensuring trust and efficiency in transactions (financial or otherwise) without the need for intermediaries or centralised control.**

The advantage of blockchain and DLT over traditional databases lies with the potential to democratise data control, creating a decentralized and transparent alternative to traditional data management. Put simply, data cannot be overwritten or altered once validated and consigned to the chain, removing the need for reconciliation checks and the risk of data loss. Blockchain-based records can provide full traceability of funds and other assets, even where trust between parties is low or non-existent.

Additional information is available in Appendix 2.

Traditional technology solutions and databases suffer from a litany of well-known problems, including data loss, data corruption or poor data entry, forcing a costly and time-consuming system of checks and balances. Moreover, most NGO systems are built by and for a single agency, resulting in duplication across organisations. Even where systems are shared, the utility of the data is limited to organisations with access to that system.

The result is that people who have benefited from assistance may not be able to benefit from the data beyond their relationship with that organization, for example to access housing, employment or healthcare, beyond the intervention.

Blockchain offers the ability to:

1. Automate processes with confidence
2. Provide real time tracking and auditability
3. Move value without the need for intermediaries
4. Maintain tamper-proof records
5. Trust records without referring to an authority

4. Applications of DLT for Humanitarian Causes

The following section provides an overview of humanitarian and NGO led interventions or projects to date which have utilized DLT for implementation. Notably, the technology has not only been used by traditional large international relief and development agencies to increase efficiency and transparency in existing programs such as CVA distribution but has also prompted a wave of new projects.

[9] Like the Humanitarian Grand Bargain, there have been many calls for the sector to become more efficient, and slow technology adoption has been identified as a challenge: Jerving, "A Strategic Mindset Shift Is Needed by NGOs to Fully Embrace Technology."

The non-profit sector is not alone in its adoption of the blockchain for positive development and environmental outcomes. Commercial 'social impact' firms are also using the technology to drive change in areas such as financial inclusion, remittances, supply chain traceability, and bond issuance. Governments are also adopting DLT based solutions for applications such as voting and land-registry; such systems could present opportunities for humanitarian organizations to further benefit vulnerable people, especially informal smallholder farmers.

Like many industries which are already facing disruption from the implementation of blockchain/ DLT, the humanitarian sector has been presented with both opportunities and challenges that have arisen from implementation of blockchain in interventions. These are presented within each of the following sections and are illustrated through project examples.

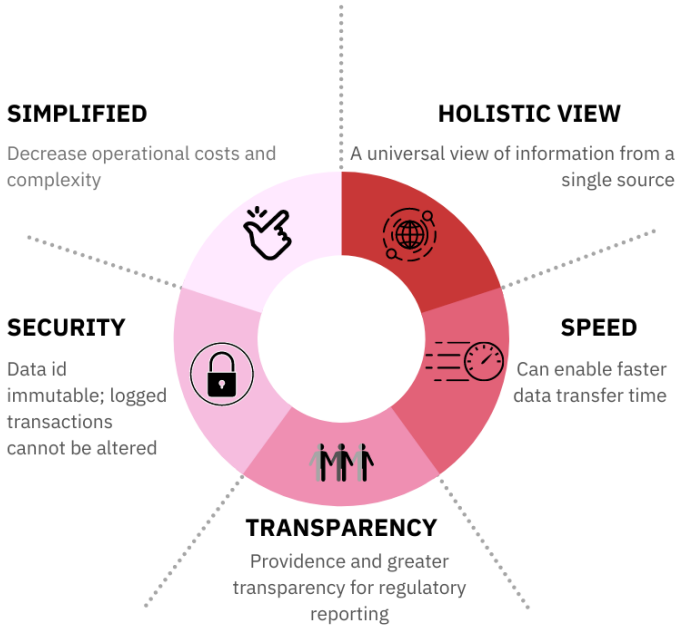
Opportunities for Blockchain/DLT in Humanitarian Interventions

"The global conversation about blockchain and cryptocurrency technologies is gradually transforming from speculative fear that "cryptocurrency is used for crimes on the dark web" to innovative intrigue that suggests "blockchain is a tool for solution enhancement and digitization."

--- Robert Greenfield IV, Emerging Impact10

There is a wide range of opportunities for DLT systems to improve effectiveness and efficiency in humanitarian interventions. These include (but are not limited to):

1. Cash and voucher distribution (CVA)
2. Donor engagement
3. Auditability
4. Identity services
5. Supply chain management
6. Community currencies
7. Natural capital and carbon tracking
8. Innovative financing and funding
9. Emerging use cases and Covid-19



1. Cash and Voucher Distribution

For traditional INGOs, the broad expansion of Cash and Voucher Assistance (CVA) programs stemming from commitments established in the 2016 Grand Bargain has led to an overall sector shift from distribution of in-kind aid to CVA. CVA totalled $5.6bn in 2019, doubling 2016 levels and accounting for 17.9% of total humanitarian assistance[11].

With the expansion of CVA, an associated need to increase efficiency and interoperability has led to exploration of digital currencies and tokens backed by the blockchain or DLT to streamline processes, reduce costs and increase transparency. CVA blockchain pilot projects have proven the potential for faster aid transfer than traditional CVA

[10] Robert Greenfield IV, "9 Blockchain for Social Impact Predictions for 2020."
[11] CALP, "The State of the World's Cash 2020."

distribution methods. One recent example of blockchain based CVA distribution is Mercy Corps' partnership with The Blockchain Charity Foundation (Binance – see box).[12]

WFP's Building Blocks provides another example. The program reported significant cost savings in CVA distribution by removing traditional financial service providers (FSPs) as intermediaries in the distribution process:

"Each beneficiary has a virtual wallet created on the blockchain and a virtual bank account. FSPs are needed only to reimburse supermarkets participating in the programme, which significantly lowers transaction costs[13]"

Mercy Corps and Blockchain Charity Foundation

This programme piloted blockchain-based distribution of CVA through pre-approved vendors for solar products, basic food items, and agricultural tools to 2,200 Sudanese refugees in Bidibidi settlement, West Nile Uganda from September to December 2019. Transfers were made by using the Humanity First Token (HFT) pegged to the Ugandan Shilling on the Binance Chain. The use of a blockchain led to significant reduction in distribution time and transaction costs while demonstrating clear improvements in monitoring and evaluation and auditability.

Oxfam's UnBlocked Cash CVA transfer program in Vanuatu found that use of blockchain

"…eliminated slow identity verifications and reduced dependency on post offices or banks to deposit cheques and/or withdraw cash" - UnBlocked Cash (Oxfam)[14]. Onboarding recipients to the Unblocked Cash platform was reduced to an average of 3.6 minutes per individual -in comparison to over 60 minutes during the Ambae volcano response the previous year.

World Vision's Sikka 2018 CVA program in Nepal further reported high time savings: The Ethereum based platform "…cut down distribution time from a whole day (considering time it would take for beneficiaries to head to the banks in district headquarters, receive payments and head back compared to the time it took for them to reach the local financial cooperative for the same) to a few hours"[15].

2. Donor engagement

Given the donor-funded nature of most INGOs and transparency commitments of the Grand Bargain, agencies are increasingly required to illustrate that donations have been used effectively and responsibly through continuous monitoring, evaluation and audits. In light of press coverage and reports on donation leakage, mismanagement of funds, corruption, and scandals - on top of high administrative and operational costs which have subsequently eroded donor confidence - blockchain is increasingly being used to restructure the relationship between donors, aid agencies and the end-recipients. From the perspective of an NGO acting as an intermediary between the donor and aid recipient, blockchain can increase the transparency in the use and distribution of funds as well as simplify and automate monitoring and evaluation of projects.

OXFAM's Smart Donations program is one example of how DLT can advance fundraising and donor engagement. The project introduces "programmable money for conditional distributions" which allow donors to set parameters such as region or type of aid around the use of their funds. Aid is returned to donors if conditions are not met in the established timeframe.[16] By using smart contracts for aid

[12] Richard Shreves, "Lessons Learned from Field Trials of Blockchain-Enabled Vouchers."
[13] Farah Awan and Soheib Nunhuck, "Governing Blocks: Building Interagency Consensus to Coordinate Humanitarian Aid."
[14] Björn Rust, "UnBlocked Cash: Piloting Accelerated Cash Transfer Delivery in Vanuatu."
[15] Saujanya Acharya. "Sikka: One Year Later, Lessons Learnt and Recent Developments."
[16] Chris Elsden et al., "Programmable Donations: Exploring Escrow-Based Conditional Giving."

distribution, donors are given more control and thereby more confidence that their donation is going directly to the specific cause they believe in. Oxfam (Australia) worked with a group of partners[17] to create a smart phone app that allows users to interact with the Smart Donations project and create event-driven conditional giving agreements powered by smart contracts.

GiveSafely has further created a blockchain based donations platform. GiveSafely allows a user to give to selected, verified charities and earn rewards based on their donation that can be redeemed for experiences. GiveSafely was founded to address the issues faced by humanitarian organizations regarding PR, trust and financing. "*The number of small donors is decreasing and giving is becoming more concentrated among the wealthy. Meanwhile younger donors are becoming more affiliated with causes, not necessarily institutions, so there is an increasing need to demonstrate the use of donations in a trustworthy way*[18]."

Another example is PolloPollo. Built on the Obyte DAG platform[19], PolloPollo promotes conditional direct giving between donor and recipient by allowing donors to select applicants who have registered at local vendors as in need of assistance[20]. *"To carry out direct micro donations like we do would simply be impossible using traditional models."*[21]

These are just a few examples of platforms developed for streamlined and transparent donations. Others include: BitGive[22] (cryptocurrency donations), GiveDirectly/Celo[23] (direct donations to programmes), Give.org[24] (charity sector research/confidence building), GiveCrypto[25] (direct donations in crypto), and LittleBitz[26] (direct donations to households and businesses).

3. Auditability, Monitoring and Evaluation

DLT offers practitioners benefits in real-time project monitoring and evaluation as well as simplifying audit procedures. In addition to savings in cost and time, it provides humanitarian organizations with the ability to analyse project data during an intervention. This enables agencies to make efficiency improvements to projects while still in progress.

Using a blockchain to store transaction data has also been shown to decrease the time and expense associated with data verification. In Mercy Corps' CVA trial in Uganda, the audit process was streamlined, due in large part to the ability to obtain verifiable data directly from the blockchain. "*The blockchain, via the relevant block explorer, provides an auditable data trail that allows near real-time tracking of the movement of funds and eases the burden of reconciliation.*"[27]

The benefits of speed and trust in the data are clearly helpful in the monitoring process, in addition to reducing the cost of reconciliation providing confidence for donors and administrators regarding use of funds.

4. Identity Services and Portable Identity

As CVA programs have grown, humanitarian agencies have seen an increased need to verify the identity of the recipient prior to distribution. Verification ensures that aid reaches those in most need, avoids duplication and

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[17] Including the Universities of Edinburgh, Northumbria and Lancaster, and research partners Zero Waste Scotland, Volunteer Scotland and WHALE Arts. See, https://oxchain.uk
[18] Interview with GiveSafely, July 30th, 2020.
[19] https://obyte.org
[20] Interview Casper Niebe, founder PolloPollo, July 29th, 2020.
[21] Interview Casper Niebe, founder Pollo, July 29th, 2020.
[22] https://bitgivefoundation.org
[23] https://www.givedirectly.org ; cLabs, "GiveDirectly to Use the Celo Platform to Help Communities in West Africa."
[24] Adrian Zmudzinski, "Charity Giant Behind Give.Org Launches a Blockchain Donation Platform."
[25] https://www.givecrypto.org
[26] https://www.littlebitz.org
[27] Richard Shreves, "Lessons Learned from Field Trials of Blockchain-Enabled Vouchers."

mismanagement, and satisfies compliance requirements such as KYC/ AML[28] and anti-terrorist financing regulations. This can be particularly helpful in identifying traditionally excluded people such as refugees or those with no financial access. To date, the collection of personal data by humanitarian organizations has resulted in large independent databases such as WFP's SCOPE (20 million IDs), IOM's Personal Identification and Registration System (20 million IDs) and World Vision's Last Mile Mobile Solution (8 million IDs).[29]

Like any international organisation, international relief and development agencies face high costs of customer onboarding, the data privacy issues inherent to identity services and the high cost of cross border exchange. Additionally, they also face unique challenges associated with their recipient population; individuals often lack formal identification, making KYC checks or authentication onerous.

"IN MOST DISTRIBUTED LEDGER TECHNOLOGY (DLT) PILOTS DIGITAL ID REMAINS THE MISSING LINK AND PROVES TO BE THE HARDEST NUT TO CRACK. HENCE THE POTENTIAL VALUE AND IMPACT OF THE TECHNOLOGY HAS YET TO BE UNLEASHED AND PROVEN ACROSS THE SECTOR..."
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Blockchain and DLT offer a potential solution. Research interviews and surveys cited identity management as a key area where NGOs could benefit from using the technology. For example, DLT can be used for secure and indelible storage of records such as identity or ownership certifications, which can be shared either with anyone, or between nominated parties, for example an NGO, merchants and government agencies. This presents opportunities not just for individual NGOs, but across the sector imagine, for example a universally available certification associated with an individual.

INGOs have not extensively explored the use of blockchain based identity solutions to date, but a growing number of private sector organisations provide these services.

Identity services currently being defined with blockchain and DLT fall into three categories:

1. Self-sovereign identity[30]: An elegant solution in which individuals control levels of access to their personal data.
2. Alternative identities: (e.g. hiveonline[31] and BanQu[32]) These services use behavioural and transactional data to provide identity.
3. Traditional identity (government, banks, etc).

Of these, the first two categories are portable, enabling individuals to use them in different circumstances and geographies. Under self-sovereign arrangements, for example, a trusted entity (or 'Oracle[33]') such as a bank, hospital or NGO can provide an individual with a blockchain certificate which can then be used as proof of identity with another institution such as a credit union, employer or NGO. There is no need to refer back to the original

[28] Know Your Customer (KYC) and Anti-Money Laundering (AML)
[29] Aiden Slavin, "Distributed Ledger Identification Systems in the Humanitarian Sector."
[30] Sovrin Foundation, "What Is Self-Sovereign Identity?"
[31] https://www.hivenetwork.online
[32] https://banqu.co and interview with CEO Ashish Gadnis on August 10th, 2020.
[33] In blockchain terms an 'Oracle' is a trusted third party that provides data for use in smart contracts.

institution[34]. A particular advantage of self-sovereign identification is that it can address concerns around personal data protection, which beforehand was a reason for selecting proprietary platforms.

Examples of such schemes include: Sovrin[35] (Self sovereign identity) Aid:Tech[36] (self-sovereign identity and donations), Shyft[37] (government digital identity), Everest[38] (Multi feature wallet with identity), Liquidus[39] (KYC) and Kiva in Sierra Leone (national identity)[40].

5. Supply Chain Management

Blockchain has already been used to increase supply chain transparency in programmes working towards fair working conditions, wage and labour law compliance, environmental conservation, climate change programs, sustainably sourced products and livelihoods programming.

Many of the efforts to date are private sector initiatives with a focus on corporate social responsibility (CSR). Consumers may gain visibility of the sourcing of products to ensure that a purchase aligns with personal moral and environmental values. For example, start-up Provenance[41] traces the origin of goods such as line-caught tuna along the supply chain via on-the-ground RFID tagging, linking the physical goods to its blockchain "digital twin".

In the non-profit sector, a similar program was instituted by World Wildlife Fund New Zealand in 2018, tracing fish from ship to supermarket for the Pacific tuna industry.[42] Heifer International has further developed food supply tracking programs with blockchain for food security and fair trade, including a partnership with Provenance in 2017. Their programs further include Project Leverage Success, which connected Honduran coffee cooperative COPRANIL to the Blockchain IBM Food Trust and Chocolate4All for cacao farmers cooperatives[43].

BeefLedger uses blockchain for ensuring quality and guards against meat fraud and safety in the Australian beef industry.[44] Another firm, Bext360[45] uses face identification to identify farmers depositing produce at weighing stations, meeting Fair Trade validation requirements.[46] Value chain traceability using blockchain can also work in reverse by showing commitments and financial guarantees which allow larger, Northern hemisphere buyers to pass on the reduced costs of borrowing down the value chain to farmers. Startup Progreso[47] has been helping coffee growers to access lending at the same low cost to their buyers by passing credit down the coffee value chain, and plans to use the technology to automate the contracts based on their crop commitments.

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[34] Evernym, "The Solution: Self-Sovereign Identity."
[35] Aiden Slavin, "Distributed Ledger Identification Systems in the Humanitarian Sector."
[36] Bob Wigley and Nicolas Cary, "The Future Is Decentralised" (UNDP).
[37] https://www.shyft.network/
[38] https://everest.org/
[39] https://liquidus.io/
[40] Matthew Davie, "Kiva's next Frontier: Kiva Protocol."
[41] https://www.provenance.org/
[42] WWF, "New Blockchain Project Has Potential to Revolutionise Seafood Industry."
[43] Heifer, "Blockchain Initiatives."
[44] https://beefledger.io/
[45] https://www.bext360.com/ and interview with Dan Jones, CEO Bext360
[46] Bext360 focuses on supply chains such as coffee, seafood, timber, minerals, cotton and palm oil to provide a traceable fingerprint from producer to consumer using a variety of blockchain interfaces, including Walmart's Hyperledger. It is also now exploring carbon tracking using the technology. EverLedger (slavery free diamonds) and BanQu are further private sector examples.
[47] https://www.progreso.nl/

Similarly, the BlocRice project in Cambodia sought to employ blockchain-powered provenance to track rice from paddy to consumer, revealing to the farmers and other supply chain actors pricing and product movement and providing retailers and consumers with traceability to origin. Since the original pilot two years ago, the platform has become commercially viable, assigning digital identities to individual farmers, giving farmers a 'voice' in the supply chain, and enabling them to optimize and grow their operations through cooperatives with other producers and access to tech solutions and extension services.[48]

6. Community Currency

Community currencies are defined by being issued by a body other than the country's central bank, for example a consortium of businesses or NGOs. They can only be spent in a limited geographical area at participating outlets. The goal of a community currency is to keep spending local, rather than being spent in large businesses which will extract profits for national or international shareholders. They are not usually legal tender, but typically can be exchanged 1:1 with national currency at participating businesses. They tend to be most successful where there is strong local support, or where direct benefits to holders are built into the currency.

Community currencies built on blockchain offer traceability - the issuer can monitor the success of the project through tracking the location and amount of transactions and how the funds circulated. A handful of projects are using blockchain to support community currencies, for example GMerits,[49] the rec(R) (Real Economy Currency)[50] project in Barcelona and Grassroots Economics[51] in Kenya (see Box below).

Grassroots Economics

Working with the Red Cross, Grassroots Economics launched the CIC program in the Mukuru area of Nairobi, Kenya in 2019. As demand rose for the community currency in the face of the Covid-19 crisis and President Uhuru Kenyatta's initiative to implement digital payments, challenges to the scalability, control mechanisms and sustainability of the platform became increasingly visible- and sparking broader debate on blockchain and DLT implementation for humanitarian use cases. The Grassroots Economics CIC has so far rolled out to almost 200k people, generating 22,700 transactions at a value of over $400K since April 2020, with plans to expand out to additional cities to support COVID response. Grassroots' bonding curve model creates complexity and potential risk. There are limited risk controls in place, and the not-for-profit organisation is run on a low budget out of donations.

Their technology, as with many NGOs, was deployed on a sidechain of Ethereum and pivoted from Proof of Authority to Proof of Stake with a small number of Oracles, which exposing additional governance and control challenges. The staking model requires a certain amount of value to be held on the sidechain, which could be routed out by this small number of oracles. As demand rose for the community currency in the face of the Covid-19 crisis and President Uhuru Kenyatta's initiative to implement digital payments, challenges to the scalability, control mechanisms and sustainability of the platform became increasingly visible- and sparking broader debate on blockchain and DLT implementation for humanitarian use cases.

[48] Mark Jones, "BlocRice - Cambodia eyes blockchain in the future of agriculture."
[49] https://gmerits.eu/
[50] https://rec.barcelona/en/home/
[51] https://www.grassrootseconomics.org/

Red Cross and Red Crescent Societies has piloted the Grassroots Economics' Community Inclusion Currency (CIC) project in Kenya[52]. Grassroots Economics is passionate about helping unbanked communities build wealth through access to credit and increased economic activity. To facilitate their objectives, Grassroots Economics created a community currency[53] which they digitalized and migrated to a blockchain-based platform in 2019.

7. Natural Capital and Carbon Tracking

A number of blockchain projects have emerged in environmental conservation and climate change. Applications are primarily aimed at reducing carbon emissions, incentivizing carbon projects, facilitating transparent marketplaces or rewarding producers of renewable energy. For example, the Global Mangrove Trust[54] reward behaviours such as taking care of trees while SolarCoin[55] focus on creating rewards for users producing solar energy.

Similarly, climate startup Nori[56] incentivizes farmers to switch to more climate-friendly land management practices by creating blockchain based carbon removal certificates and an accompanying marketplace for C02 removed from the atmosphere.

8. Innovative Financing and Funding

The World Bank's first blockchain based bond[57] was issued without the need for a custodian. international relief and development agencies could similarly reduce the need for traditional intermediaries, reducing cost and enabling them to focus more on their key human-facing activities. The Danish Red Cross is now advancing the concept further with its Volcano Catastrophe Bond[58]. (See Box)

Blockchain offers the ability to fractionalise assets, as the cost of an individual contract is not related to how many there are, and without the need for intermediaries, processes can be automated with confidence. This makes 'securitised tokens' possible, which enable large numbers of people to buy small fractions of a security. This approach could offer opportunities for much broader fundraising activities for NGOs. Social applications like this could be of interest to NGOs, for example with large

Volcano Catastrophe Bond

In November 2018, the Danish Red Cross and British Red Cross partnered with Mitiga Solutions and REplexus to design and develop a blockchain enhanced parametric volcano catastrophe bond (CAT bond). The bond is the first of its kind in the humanitarian sector and opens new possibilities for the sector in terms of access to capital markets through Insurance Linked Securities (ILS) to mitigate exposure to risks from crises and disasters.

Ten volcanoes are included in the CAT bond, selected on the basis of their proximity to vulnerable communities and potential for humanitarian intervention. The bond is triggered on the height of the ash plume following an eruption with payout made to the sponsor, the Danish Red Cross, which then has rapid funding for needed humanitarian response programs. The Volcano CAT bond was issued over the ILS blockchain, **reducing costs by US$200,000 to US$400,000 per issue in comparison to traditional settlement systems.**

[52] In August 2019, the Danish Red Cross, together with Kenya Red Cross and Norwegian Red Cross partnered with Grassroots Economics, Innovation Norway and Doen Foundation to finance the expansion of Community Inclusion Currencies.
[53] Also known as a "complementary currency."
[54] https://globalmangrove.org/
[55] https://solarcoin.org/
[56] https://nori.com/
[57] Reichelt, "World Bank Issues Second Tranche of Blockchain Bond Via Bond-i."
[58] Danish Red Cross, "Parametric Trigger – Volcano Catastrophe Bond."

numbers of individual donors having the ability to participate more directly in interventions through a crowdsourcing approach.

9. Emerging Use Cases and Covid-19

Universal Basic Income is another potential use case that may be of interest to the NGO sector, although to date projects have been in the academic or government domain. An example is in the Spanish **rec** project[59] which is also being used to distribute government support to businesses and individuals in the COVID-19 crisis, while GoodDollar[60] is a Universal Basic Income project aiming to support anyone who signs up.

Several of the NGOs and startups involved in our study (including Oxfam, BanQu and Bext360) have been using their DLT platforms to support distribution of personal protective equipment (PPE) or money to communities impacted by the COVID crisis, and there is further opportunity to do so across many programmes.

Digital platforms, especially with the inbuilt trust that comes with DLT, are also useful tools for managing community activities remotely, such as savings groups or cooperatives, in order to maintain financial resilience and community functions such as voting, without the need for physical meetings. hiveonline's savings group platform is an example.

5. Challenges in Blockchain/ DLT Humanitarian Project Implementation

While the benefits of applying DLT in humanitarian use cases are clear, there are challenges in implementation. The challenges range from issues with the technology itself to introduction of unforeseen risks in project implementation arising from limited regulation and the by-passing of traditional institutions (for example, by passing banks in a digital CVA distribution). Risks are particularly acute in financial activities, including CVA or community currency. Additionally, identity services carry concerns around personal data protection and GDPR.

Distributed ledger technology is relatively new and rapidly evolving. Most NGOs are still exploring what works. Many of the DLT projects run by NGOs have not fully realized the benefits of decentralisation and universal availability of data; typically this has been the result of the use of closed systems that restricts access to their platforms. **Even where there is a proposal to collaborate, the underlying assumption is often that the organization owns the system, making it effectively proprietary.** For example, the WFP's Building Blocks CVA platform is running on a single node on an Ethereum fork, losing the benefits of decentralization[61]. This section looks into the main challenges faced by humanitarian stakeholders, including both the technology itself and issues of implementation.

[59] Interview. Susana Martin Belmonte. GEMERITS. 27 August 2020
[60] https://www.gooddollar.org/
[61] David Gerard, "The World Food Programme's Much-Publicised 'Blockchain' Has One Participant — i.e., It's a Database."

Technological Challenges

1. Technical Limitations of Existing DLT Platforms

Of the projects implemented by INGOs to date, most have initially used Ethereum or derivations of Ethereum[62] although some have since migrated to other platforms. Our survey respondents noted that the transaction costs associated with Ethereum led to pilots running into issues when scaling. A lack of transparency in governance also led to unanticipated changes to the underlying platform that negatively affected some projects. Research indicated that the cause of many of these issues was Ethereum's choice of consensus protocol[63], Proof of Work. Ethereum offers ease of use but its protocol is computationally expensive and uses a lot of energy, leading to low throughput and high costs.[64]

Fluctuation of transaction costs has been a key challenge. Because of limited transaction throughput, some blockchains are subject to surge pricing, which can send fees skyrocketing, leaving lower-paying transactions orphaned. Additionally, the business model of some DLT networks applies high charges to data storage. Other activities like arbitrage can also push fees up. A DLT designed specifically for the needs of humanitarian organizations could provide a solution to this problem.

Other blockchain structures, like Hyperledger Fabric and JP Morgan's (now Consensys') Quorum, have improved throughput but, as they are private, permissioned blockchains, they have done so at a cost of accessibility and anonymity. While these DLTs may be an attractive option for enterprise applications, they may not offer the reach and low barriers to entry required by NGOs to be of benefit to large numbers of people in rapid deployments. Emerging protocols and non-blockchain DLTs such as DAGs can offer both high throughput and accessibility, but without the easy to use tools provided by platforms like Ethereum or Hyperledger Fabric.

2. Energy Usage

The high energy consumption of blockchains that employ Proof of Work, like Bitcoin and Ethereum, has attracted significant bad press for blockchain. The yearly energy consumption of Ethereum is on par with the entire country of Panama[65] while Bitcoin has a carbon footprint comparable with Tunisia[66]. Given these figures, humanitarian stakeholders with environmental focus have rightfully been sceptical of the usage of blockchain. However, blockchains that use alternative consensus protocols do not suffer from this high electricity consumption because the protocols rely on alternative ways of proving commitment to the network[67].

THE YEARLY ENERGY CONSUMPTION OF ETHEREREUM IS ON PAR WITH THE ENTIRE COUNTRY OF PANAMA

[62] Examples include WFP Building Blocks, Oxfam Unblocked Cash, World Vision Sikka and Red Cross Red Crescent/Grassroots Economics CIC

[63] Different consensus protocols are presented in Appendix 2.

[64] The TXStreet visualisation shows live throughput of major blockchains, demonstrating the usual excess in transactions and variable/rising costs of transactions that results from this restriction.

[65] Digiconomist, "Ethereum Energy Consumption Index (Beta)."

[66] Digiconomist, "Bitcoin Energy Consumption Index."

[67] And indeed, may soon disappear for Ethereum, as the project roadmap calls for abandoning Proof of Work in the near future.

Implementation Challenges

1. Unfamiliarity with the Technology

It cannot be overstated that blockchain and DLT are complex and the technology is currently developing rapidly. Despite the growing number of pilots, overall knowledge of the technology remains low and application of DLT in traditional INGO projects is limited.

Survey and interview responses indicated a general lack of education about or support for using DLT in project design. In some cases, this lack of familiarity has led to overreliance on external consultancies (or a few individuals). As a project report from Oxfam/Australian Aid put it:

"A consequence of these complexities was Oxfam's immense dependence on [the vendor's]'s core staff, who travelled to Vanuatu for the duration of the pilot. The co-founder turned out to be an indispensable asset for even the smallest technical support queries. One Oxfam staff member based in Vanuatu anecdotally estimated that the co-founder was the only person able to solve the problem at hand in all but a few occasions. When asked if Oxfam staff could be trained to respond to these issues they replied, "Yes, but we didn't know what they would be until they emerged"[68].

2. Proprietary Systems

One of the key challenges observed through the research is that closed, permissioned systems deliver fewer benefits than more open approaches. The decentralized nature of the technology is one of its key advantages. However humanitarian projects to date have often not exploited it. For example, while WFP's Building Blocks reported significant time savings in CVA distribution through its programs in Syria and Bangladesh, the architecture of the blockchain used is not truly distributed.[69] The benefits of decentralization, openness, and collaboration were therefore missed. Platforms like BanQu, Bext360 and Provenance are helping to build trust across multiple organizations, benefitting many actors across value chains and different sectors – but this can only be achieved where data is accessible to multiple parties.[70]

3. Funding for Qualified Teams and Reliance on External Consultancies

As most international relief and development agencies tend to lack advanced technical capability, many of the projects studied have partnered with a limited number of DLT development consultancies to fill these gaps, but software development is expensive. Donors typically prefer to see their money go to direct action in countries, rather than building tools or infrastructure. While NGOs could eventually develop internal capability, the size and scale of most projects make this impractical for all but the largest INGOs.

4. Regulation Challenges

There are also concerns about how global digital currencies might negatively impact the stability of local currencies, particularly in smaller nations. Although NGOs have always moved money into developing economies, the accessibility of automated digital money presents a risk of flight to that currency from less stable currencies;

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[68] Björn Rust, "UnBlocked Cash: Piloting Accelerated Cash Transfer Delivery in Vanuatu."
[69] Farah Awan and Soheib Nunhuck, "Governing Blocks: Building Interagency Consensus to Coordinate Humanitarian Aid."
[70] That said, one benefit of closed systems is low risk of exposing personal data to third parties, however this can potentially be overcome using Self-Sovereign Identity. See, Sovrin, "What Is Self-Sovereign Identity?"

this is one of the major concerns for developing countries when contemplating privately issued currency such as Libra[71].

As demonstrated by the projects in the case studies, NGOs are negotiating with regulators to find solutions at a project level, however to be effective, there is a need for a systemic approach to the use of this technology in humanitarian scenarios. International organisations such as the UN's Digital Finance Task Force[72] are advocating for progress and it will be important for the humanitarian sector to have a voice in this advocacy.

5. Barriers for Low-Tech Users: Infrastructure and Environment

Humanitarian aid and development agencies routinely work in some of the most challenging environments on the planet, and across the broadest range of technology landscapes. In many places, internet access is limited to mobile devices; in other places, it's not available at all. In some locations electricity is less than reliable, or may be closely rationed. Similarly, mobile coverage may be spotty or non-existent, or the cost of mobile phones or data plans prohibitively high. These environmental constraints require an approach to technology that is driven by fitness for purpose and, while technology progresses and problems like these tend to be reduced over time, the issues will remain significant for the foreseeable future and are likely inevitable in the context of emergency relief in the wake of disaster.

NGOs in the successful case studies have overcome this challenge by employing a variety of non-DLT techniques designed to address specific challenges, for example:

- Using QR codes to make transactions easier for low literacy user
- Use of iris recognition to make authentication simpler
- Creation of icon-driven mobile interfaces
- Setting up Wifi repeaters and range extenders
- Resorting to USSD[73] as a method for moving data

While the solutions outlined above helped agencies overcome some of the problems, these adoption challenges increase costs, create uncertainty and make the use of DLT-based modalities less attractive.[74]

6. Perception Issues

To some in the sector, the blockchain version of DLT has a tarnished reputation. Whether it is because of Bitcoin and other cryptocurrencies being used by unsavoury characters for illegal trade, the ICO rush[75] of 2017-2018, or the considerable number of Ponzi schemes in the cryptocurrency space, the PR has been far from ideal. While the

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[71] Libra will be escrowed against fiat currencies, so will be an attractive alternative to the US Dollar or Euro which are used alongside national currencies in developing economies, but are less accessible than a digital currency.
See, Coindesk, "Libra Hasn't Abandoned Multi-Currency Stablecoin: Policy Director."

[72] Task Force on Digital Financing of the Sustainable Development Goals, "The People's Money: Task Force On Digital Financing Full Report"

[73] A short messaging protocol similar to SMS

[74] A number of respondents also flagged the usability of existing applications that employ DLT as problematic. Barriers for vulnerable people include low levels of technical, numeric and functional literacy. While those points are valid, and the barriers meaningful, those issues relate to the usability of the software built on top of the platform, not the platform itself, and hence are outside the scope of this paper.

[75] Creighton, "The Evolution of the ICO, an Analysis of the History and Trends to Date."

proliferation of fraudulent and insubstantial offerings has died off thanks to regulation[76] and better-educated investors, some in the sector are still wary of the technology. Nonetheless, as awareness of the benefits increases and more substantial and credible projects adopt this technology, it is expected that these perception issues will ease with time.

Overcoming Challenges Through Collaboration

Figure 2: Humanitarian Blockchain Collaboration Timeline

Short and Long-Term Programmes

Traditional humanitarian interventions are often short-term distributions of aid to vulnerable populations following a crisis. There is growing awareness of the importance of linking short-term distribution with long-term development through market-based approaches and livelihood development. Blockchain and DLT solutions have the potential to assist in linking the two categories of interventions, but wider, long-term planning is required to develop solutions that can transition from one to the other as well as to ensure scalability and ease of replication across contexts and regions.

Preventing Duplication

Historically, NGOs have collaborated on interventions, particularly disaster relief but often duplicate activities such as registration of vulnerable people on multiple systems, incentivised by the donor model. The structure, timelines, and restrictions created by the donor funding cycle also tend to favour short-term pilots or programs designed in siloed approaches that have failed to reach their full potential and score low on scalability and replicability. A shared humanitarian blockchain offers a potential solution to this problem, enabling multiple actors to leverage a shared infrastructure and, in appropriate cases, data.

Reduce Inefficiencies and Increase Transparency

A lack of collaboration in existing projects, seen in refugee camps all over the world, is failing to realise the potential benefits of DLT. At present a person with an identity on an NGO's platform could not use that identity to obtain a government registered ID without that government subscribing to the NGO's platform. Moreover, as the NGO's identification standards may be different than the government's or the bank's, those institutional actors may not accept the validity of the NGO-generated identity. For the very same reasons, if that person interacts with another NGO, that second NGO may not accept the person's identification generated by the first NGO.

While a shared humanitarian blockchain would go a long way to solving this problem, the problem goes beyond technology. The dynamic of competing for donor funding leads to a competitive, proprietary approach characterised by the desire to own IP and control access to recipients. To fully realise the benefits of DLT to humans, the data pertaining to

[76] Although regulators are beginning to classify Security Tokens and other digital assets for the purpose of regulation, the landscape is still evolving and differs from country to country.

them - identity, stores of value, certifications - must be openly available beyond the control of a single, or even consortium of NGOs, which implies an open platform supporting them.

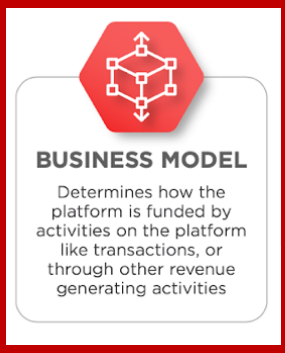
With the Private Sector

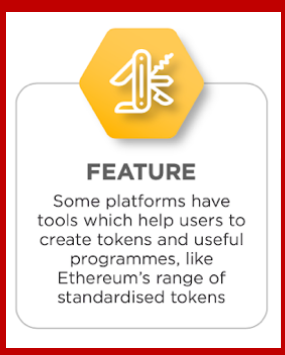
A growing number of private sector companies are applying blockchain technology for social impact, for example in healthcare, education, rights affirmation, value chain traceability, financial inclusion, identity and many other areas. Given the overlap of values and interest, increased collaboration between these entities could lead to improved results from both private sector impact firms and INGOs. However, partnership between the two sectors has been limited to date.

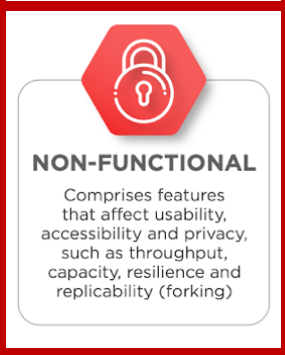
The existence of a shared humanitarian blockchain would provide a platform for strategic partnerships and amplify benefits through technology knowledge sharing, sector-specific expertise, and long-term business models for more market-based interventions. Private firms would benefit from the ability of INGOs to reach customers at the last mile, in particular, and NGOs would benefit from access to the wealth of expertise and innovation that exists in the private sector.

Part Two

A Distributed Ledger for the Humanitarian Sector







6. Looking Forward: A Shared Humanitarian Platform

Despite the many challenges faced by INGOs and social impact businesses in the early years of implementing blockchain-based interventions, clear benefits have been achieved. Research respondents agreed that the potential for blockchain or DLT based solutions to benefit humanitarian and impact projects remain significant. Early projects, as could be expected, have delivered the important lessons needed to inform more effective future use of the technology.

The authors propose the creation of a common platform designed for humanitarian use cases. Based either on a new or repurposed platform, it would bring much needed efficiencies, and improve trust and cooperation between NGOs, social impact businesses, donors and most importantly people in need.

While no existing commercial blockchain or DLT solutions were found to fully align with the unique requirements of the humanitarian sector, detailed in the next section, a variety of existing platforms have partially met the needs. For example, Ethereum's easy to use token structures and many sidechains, Hyperledger's Open Governance model and Hedera Hashgraph's high throughput and low transaction cost are all features beneficial to humanitarian use cases. On the other hand, Ethereum's high transaction cost and energy usage, Hyperledger private-permissioned structure and high price tag, and the corporate governance structure of Hedera Hashgraph make the full implementation of these blockchains and DLT less than ideal for humanitarian needs in the long term.

As a starting point for the discussion, it is important that any solution established should be consistent with the values of the humanitarian sector[77]. The Red Cross and Red Crescent Movement defines seven fundamental principles at the core of their approach to helping people in need; these include: humanity, impartiality, neutrality, independence, voluntary service, unity and universality. In addition, the platform must be consistent with the fundamental concept of "do no harm".

Desired Use Cases and Platform Requirements:

Use Cases:

While suggested use cases for blockchain and DLT tended to mirror the current use cases, survey and interview respondents highlighted some key differences in ranking of use cases and future potential from those projects which are currently underway. Specifically, participants identified "**identity services**" "**supply chain management**" and "**cash and voucher distribution**" as the top use cases.

[77] "Generally speaking, there is usually a huge disconnect in ethics between the providers of the technology and the humanitarian mission. Mediators are necessary, who understand both sides. It is a rare event that the technology provider only works with humanitarian organizations, and thus often forget the lack of technological understanding the users might have. And what infrastructures exist already." -Julia Evelyn Larsen (from Survey)

In open questioning, respondents additionally expressed support for applications including donor relations, low cost transactions and remittances and streamlined accounting. There was further broad support for digital certification and issuing of credentials.

Platform Requirements:

The research identified the following requirements for the platform:

ACCESSIBILITY

Ease of use for both organizations and end-users is important, particularly taking into account the potentially low technical literacy of vulnerable people. This includes a solution architecture suitable for the broad variety of challenging operating environments in which many NGOs operate.

SIMPLICITY

Ease of deployment without a large investment in technology

AFFORDABILITY AND COST PREDICTABILITY

For humanitarian organizations and, in the case of sustainable business models, for the recipients/customers.

SCALABILITY AND THROUGHPUT

Essential for large volumes of transactions

ACCOUNTABILITY AND TRANSPARANCY

For humanitarian organizations, donors, regulators, governments, and the vulnerable people who may be supported by the platform.

ENVIRONMENTALLY SUSTAINABLE AT SCALE

Avoid the high energy consumption associated with certain consensus protocol systems.

INTEROPERABILITY

To be useful to the humanitarian sector, a platform should be able to interface both with existing networks (such as payment gateways, government identity, property, taxation and health repositories, commercial trade value chains and with other blockchains,) as the technology proliferates across the private sector and into the decentralised economy.

7. Collaborative Development of the Humanitarian DLT

Discussion around the structure and implementation of any proposed DLT solution should involve humanitarian organizations and stakeholders to ensure cross-agency commitment and coordination, usability and use. For this reason, the first stage of creation of a DLT for the sector was the establishment of a multi-stakeholder committee that is collaborating on this research project. This collective (or working group) will transition into a governance structure for the DLT which will coordinate the wider discussion on implementation particulars.

It is important that in addition to a technical discussion on the structure of the platform, materials and best practices should be developed to guide sector actors in project implementation, both for the new platform and for humanitarian organisations currently running or considering blockchain projects. The guidance should include:

EDUCATION

for key stakeholders on the capabilities, benefits and risks of using DLT technology and features of the different platforms available.

OPERATIONAL GUIDANCE

on how to manage platforms with financial or data impact, that meet criteria for regulatory oversight.

LEGAL AND REGULATORY GUIDANCE

on the pitfalls and implications of using the platform for personal or transaction data.

FINANCIAL AND DATA MODELING TOOLS

or large scale projects based on blockchain.

CREATION OF DEVELOPMENT TOOLS AND RESOURCES

GUIDANCE ON DIGITAL LITERACY

for people using the solutions

Structuring the Humanitarian DLT

This research took the first steps towards identifying key characteristics of a desirable solution. It reviewed existing solutions for key characteristics including scalability, cost, volatility, security, governance and business model. However, this is simply a baseline on which a collaborative conversation must build. It is necessary to make decisions in the following areas: permissions, governance, consensus, utility, and business model.

As seen in **Part 1**, a self-sustaining digital platform will need to address these problems in several layers:

GOVERNANCE LAYER

where there is no possibility of a single party or cartel taking over decision making on the operation of the platform.

BUSINESS MODEL LAYER

where operating the platform generates enough income to support continued operation and reasonable growth.

FEATURE LAYER

where the platform is sufficiently usable and useful to present a low barrier to entry

NON-FUNCTIONAL LAYER

layer where throughput and cost are at levels that are attractive to scale even for very low value transactions.

TECHNOLOGY LAYER

where consensus protocol and instruments are self-regulating, with feedback loops penalising bad behaviour and rewarding good behaviour.

8. Governance Models for Humanitarian DLT

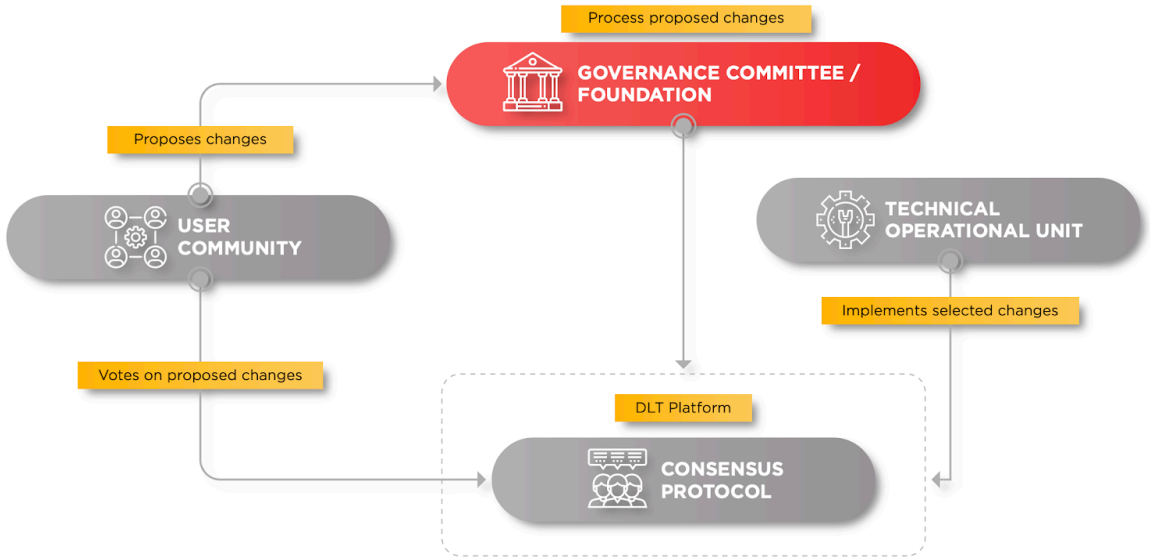
The governance responsibility for a distributed ledger differs from those of other forms of humanitarian collaboration or inter-agency committee. The governing body of the platform is primarily required to make decisions on the strategic direction of the platform, including maintaining its applicability and usability, and for legal and regulatory representation. Decisions would include pricing, certification of assets with regulators, changes to consensus model or throughput, creation of new tools or any other technical or operational changes to the DLT.

Proposals for changes to blockchains are typically invited from the user community and subject to some form of voting. Decision making for existing blockchains varies from completely distributed, where every user has the opportunity to vote on changes, such as the Bitcoin blockchain[78], through to centralised decision making, albeit with user engagement, such as Stellar Foundation[79]. Most blockchains run by private companies determine changes centrally.[80]

Governance vs Consensus

In blockchains, operational processing governance is built into the consensus protocol as a design feature, controlling the decision-making process of validating and authorising transactions. Governance for operation of the platform, and most importantly, changes to design features including the consensus protocol, is handled separately. Governance for blockchains is often conflated with consensus protocols, however it's important to recognise transaction governance and business model/ operational governance as two distinct frameworks.

Figure 3: DLT Governance and Protocol Structure



[78] Ben R. Craig and Joseph Kachovec, "Bitcoin's Decentralized Decision Structure."
[79] Stellar welcomes input from its user base and has a peer-voted grant structure for certain projects, but core infrastructure changes and the promotion of preferred currencies are controlled by the Foundation through an opaque selection process. Stellar Development Foundation, "SDF Mandate."
[80] As blockchains have inbuilt consensus systems suitable for voting, many use the consensus protocol for voting about changes on the blockchain, as a way of engaging users in decision making.

Governance Structures for Consideration

Several public blockchains are governed by a **Foundation** which is a collection of interested parties responsible for making key decisions, managing voting, and management of core teams (which are often themselves distributed). The composition of foundations and voting rights of members influences the direction in which the technology and business objectives evolve.

Many more blockchains are operated by private companies. Private sector operation offers the advantages of responsiveness to user needs and faster decision making, but also the risks of prioritising commercial interests, the likelihood of business models being redesigned and a potential lack of longevity of support.

Governance supporting the proposed platform should uphold RCRC values, in particular independence, inclusivity, neutrality, transparency, accessibility and "do no harm". Based on the many actors involved in the humanitarian sector - donors, NGOs, private companies, Civil Society Organisations, governments, etc. as well as the needs of the supported populations, a governance structure including representation of all stakeholder groups, including those impacted, would be most likely to support these values and the goals of the platform.

Convening and maintaining engagement of any community requires incentives for that community to continue to be engaged, and lessons can be drawn from the models presented in Appendix 3 about how to maintain this engagement through voting rights and accountabilities. The collaborative nature of this community also presents an opportunity for a body of knowledge to be collected and made available to the public, including technical documentation and training materials to support organisations using the platform.

Examples of governance drawn from Stellar, Ethereum, Libra, Hedera Hashgraph and Hyperledger are shown at Appendix 3.

9. Business Model Considerations

DLT business models differ from traditional technology platform business models in several key ways, due to their distributed nature and the complex relationships between value generation and management. This section looks at a number of these business model considerations and the cost implications associated with each.

Platform Setup

The build (or repurposing) of a DLT platform and the supporting utility layers is an expensive undertaking; scoping that cost will depend on the next stage of research/design. Time must be spent selecting the optimal technology and designing the economics, governance and operations. Determination of possible sources of funding for the design and build will need to be addressed as part of the next phase.

Operational Considerations

Humanitarian organisations have specific business model needs, including low transaction costs and cost predictability for both transactions and any digital asset being used. Moreover, where NGOs are hosting nodes, most will likely need operational support as node operations are outside the core competencies of traditional IT teams. A balance has to be struck in terms of costs and sustainability. Funding certainty is essential for the platform to avoid running the risk of defunding.

Transaction Prices

Transaction pricing is a critical factor in DLT design. Some platforms include a mining incentive, as well as a transaction fee, designed to incentivize network participants to maintain nodes and to mine or validate transactions[81]. The incentives are usually paid to the nodes which validate or mine the blocks, and are usually paid by the originator of the transaction. However other models can apply, for example with Ardor[82], the operating platform can carry the transaction fees. Some, like Ethereum, have a structured set of pricing for different types of transactions (although still subject to surge pricing).

Network fees also play a role in disincentivizing certain negative behaviours, for example, spamming the network with large numbers of small transactions, or inappropriately using the blockchain for storage of data. Accordingly, a balance has to be struck -- a balance between platform sustainability, incentivizing node operators, and discouraging bad actors.

Native Currency

A decision must be taken about whether to include a cryptocurrency as a unit of value on the platform. The purpose of a cryptocurrency is to incentivise actors on the network to keep the network going, providing a strong rationale for creating a unit of value, however it can also lead to speculation, and arbitrage, creating runs and volatility, which would be detrimental to use as an instrument for low-value transactions. Blockchains can run without cryptocurrencies, but lacking the financial incentive, would need to provide another incentive for validators. Hence, the industry assumes that all public blockchains run cryptocurrencies. In a private structure, a cryptocurrency is not needed. However, it is also possible to impose volatility controls on a cryptocurrency through a variety of mechanisms[83], such as staged release of predetermined units of currency[84], or pegging controls, as seen in stablecoins.

Overall, these costs must be matched by, or, where a profitable model is needed, exceeded by, the income coming in from transaction fees. These fees can fluctuate depending on demand, or else be flat fees, exchange fees (if relevant), sale of native cryptocurrency, software/wallet licencing or commercial partner financing, for example partners agreeing to absorb incentive costs.

Flat fees on transactions and exchange fees, together with sales of native cryptocurrency in the early years, are options which would encourage wide participation. A low-cost, low-environmental impact protocol, together with a pruning capability would minimise costs and hosting challenges. This will both reduce the cost to validators and make the range of devices on which a node can be hosted cheaper. The recommendation for a specific protocol is not in scope for this report and will be subject to the next phase.

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[81] In blockchains, a block of transactions is "mined" by nodes, which are incentivised by a reward in cryptocurrency; node validators then validate the block, and propagate it to multiple other nodes. In non-Proof of Work protocols, any node can be a miner or validator, however Proof of Work mining requires significant computing power, hence mining rewards are greater in PoW.

[82] https://www.jelurida.com/ardor

[83] Where the value of a fee rises and falls with demand, the transaction fees that users are willing to pay will also rise, incentivising validators to select transactions with higher associated fees. For this reason, fluctuating fees are not recommended.

[84] Many chains retain a store of the native currency specifically to release for future funding rounds. While this is standard in the early stages of a chain's growth, it is not indefinitely sustainable.

Operations, Support, and Maintenance

Regardless of the level of coding that is contributed by the community, a core team is necessary to manage upgrades, maintain testnets[85], run organisations, and carry out marketing, accounting, legal, and membership functions. This represents a cost to the network, which must be realised from some mix of the following:

- Charges to users (as Ethereum does)
- Grants, sponsor or venture funding

Other finance raising activities, such as selling cryptocurrency from a reserve stock (as Stellar does.)

Humanitarian DLT as a Common Good?

The UN Secretary-General's Digital Cooperation Roadmap recommends that common goods, or utilities that can be accessed by any parties, should be open source with open governance[1].

As a public, common good, the full benefits of a DLT platform could be realised, including open availability of data across agencies so that vulnerable people can access services more easily and to reduce inefficiencies and duplication:

- Access to a single view of a certificate pertaining to an individual, across borders, across NGOs and in the post-relief world of governments, private sector companies, financial and educational institutions, healthcare providers and more[1].
- Universal access to digital twins or certifications of ownership, carbon credits, vaccination, qualifications, ethical standards, etc - for people, produce and other assets,
- Store of value owned by the individual, not tied to any bank or single operating entity

However, there would also be risks:

- Open means accessible to all, including private sector, governments and potentially bad actors, although DLT is designed to prevent bad actors influencing direction.
- Open availability of data would risk poor project design or lack of encryption exposing personal data for vulnerable people.

As Nick Byrne[1] of Type Human says:

"By building things that are free and open we are contributing to innovation commons, but that comes at a cost. There are other systems we would have to build to manage those risks."

[85] A testnet is a dummy replica of the main DLT (mainnet) used for testing by organisations developing applications on the distributed ledger.

10. Conclusions

Overall, challenges with use of the technology by the sector are associated with how it has been implemented and poor image, rather than inherent issues with the technology. which presents many opportunities relevant to the needs of the sector.

1. These are Early Days for Humanitarian Blockchain Projects

Humanitarian organisations have had a level of success with blockchain projects, which have provided opportunities to realise benefits and learn about the opportunities presented by DLT and blockchain. However, because of the experimental nature of the projects and the early stage of development of the technology, organisations have naturally been cautious about exploiting some of the transformational benefits, such as open availability of data, which could reduce costs and duplication, and improve transparency across the sector and beyond.

2. The Perfect Humanitarian Blockchain has not yet been Identified

The first and second generation of blockchains have presented a variety of challenges to the sector, including cost, environmental impact and usability. The technology is addressing some of these problems. However, some new generation DLTs which provide high-throughput, low-cost transactions (Stellar, Hedera Hashgraph) present usability challenges and lack the commonly used tools available on Ethereum.

3. Structural and Capability Changes will Realise Greatest Benefits

A key challenge for the humanitarian sector in using the technology, is that significant opportunities of reduced duplication and benefit to vulnerable people beyond humanitarian intervention can only be realised in a model where data is transparent and generally available, implying that a single project could be funded by one agency, but benefit many, which does not match today's funding model, where NGOs have to report benefits of a given implementation to donors. Linked to this challenge, is the risk implications of managing data, including financial transactions, on an open, unregulated technology with no inbuilt risk controls.

Closed, proprietary systems will fail to realise the maximum benefits of DLT for the humanitarian sector.

4. Solutions are Available and the Benefits are Significant

Each of these challenges is addressable, and the overwhelming consensus from survey and interview participants across multiple sectors has been that the potential benefits of the technology to the international relief and development sector could be significant. Furthermore, while many challenges have been experienced, for each of these challenges there are examples of NGO or private sector projects which have begun to overcome them.

A combination of the right governance model, the right business model and the right technology, supported by relevant services, could give the sector a tool with the capability to reduce costs, increase donor confidence and, most importantly, bring significant benefits to vulnerable people.

In conclusion, the available evidence suggests that there is a strong case for progressing beyond this research to expand upon the recommendations presented in this section, into a more detailed governance, business, economic and technical design phase.

11. Recommendations

As a result of this research, the authors recommend that any future DLT platform designed for large scale humanitarian use would need to conform to the following findings.

1. Choice of Platform

Transparency and accessibility of data across organisations is a prerequisite for the Next Generation Humanitarian Distributed Platform. This is likely to exclude the use of proprietary platforms. In the short term, adoption of one or more low cost existing platforms, including existing tools that can support CVA, could provide immediate sectoral benefits while the sector considers the development of a more dedicated platform. Based on the current advances in the technology, the sector will benefit most from adopting more recent developments, which reduce cost, and increase throughput and stability of DLTs.

2. Governance

From the options available for governance across both proprietary and public good platforms, the Foundation structure would be most suitable, because it prevents the governing body becoming a profit centre and allows for member driven decision making. It should include:

- A Governance Committee, responsible for upholding the key principles and values
- A Technical Committee, responsible for reviewing proposals from the community for enhancements and changes to the platform
- A Member Council, representing all stakeholders on the platform.

Lessons learned from the analysis point to the need for a hands-on operational team designed for day to day operational decision making. Membership should include a broad range of relevant stakeholder groups to ensure representation across the ecosystem supporting vulnerable people

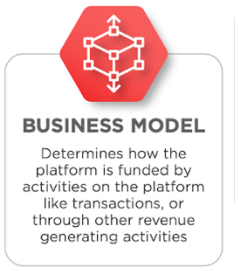
- INGOs, UN agencies; donors; Social Enterprise businesses; Private Sector tech companies; Academic institutions; Legal; Bloc representation (African Union, ASEAN, European Commission, etc); Central banks/regulators from developing countries and IFIs.
- Representation from a range of sizes of organizations - NGOs and private sector.
- Citizen representation from developing countries (small local NGOs and impact startups).

It should include the collation of educational materials for organisations planning to use the platform and to encourage ongoing development of both the platform and applications using the platform, create and distribute developer training, documentation and APIs.

In light of the many legal/regulatory questions involved in both governing and using a DLT, group of legal representatives familiar with the constraints and regulations related to blockchain platforms and assets in different jurisdictions to advise the governing body and implementing organisations should be convened.

The governance structure must uphold the principles of “Do no harm”, independence, inclusivity, neutrality, transparency and accessibility

3. Business Model



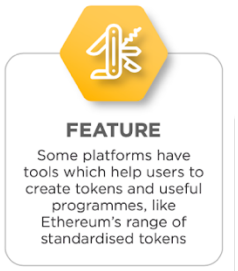
Investigation into funding models will need to consider the initial platform set-up as well as the longer-term revenue model. Grant funding may present a short-term opportunity for initial setup, but longer term a sustainable model will be needed.

It is recommended that the need for a cryptocurrency, with controlled volatility, is assessed, as this would enable low transaction fees offsetting the cost of running validator nodes for network hosts.

A high throughput, low transaction cost solution offers the best model for financial sustainability. However, with currently available platforms this involves a penalty in usability and a solution to that problem must be found

As there are strong arguments for and against open source, we recommend referring this decision to the governing body for further analysis and consideration

4. Features



Feature recommendations comprise:

- An application layer with plug-and-play features such as wallets, dashboards and user management
- A toolset of tokens to support the key humanitarian use cases identified, including "digital twin" for value chain, a stablecoin and other stable value tokens for CVA
- A non-Proof of Work consensus protocol, which does not encourage a tendency to centralisation, with a security protocol that allows for high network throughput such as Federated or Asynchronous BFT
- Easy to use development tools and APIs
- Identity features which meet personal data protection needs (e.g. Self-Sovereign Identity, GDPR)

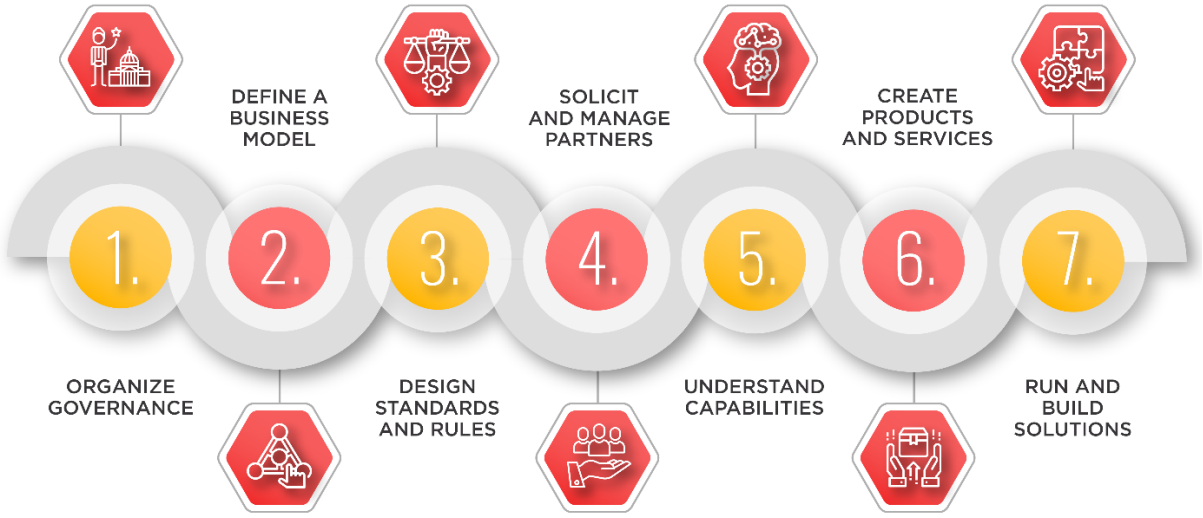
5. Operational (Non-Functional and Technical)

We recommend high throughput, low energy transactions, and maintaining low volatility of e.g. value, and automatic swaps. It should be convenient for organisations hosting nodes in order to encourage a large number of hosted nodes[86] and able to run on lower capacity devices[87] through options such as a pruning capability[88]

[86] DAGs and sharded consensus protocols increase their throughput with a greater number of nodes, however conventional PoW consensus could slow down with more nodes because of the need for half the network to validate transactions.
[87] If a network such as the Bitcoin blockchain is adding 1mb block every 10 minutes, it could in theory grow by 525 gigabytes a year, before any processing takes place (although it's currently less than 300 gigabytes).
[88] Some blockchains have the facility to remove non-critical data from some nodes, aka pruning.

12. Next Steps

To achieve the goals of this paper, there is a need for a more detailed level of design, to be built through a collaborative team of key stakeholders, with dedicated time and resources. These next steps are:



1. Create a working group of key stakeholders to build on this research in a structured investigation. Membership should be based on the group convened by Mercy Corps previously along with the participants in this study and additional interested stakeholders. The group should represent diversity in many dimensions including:
    - Geographic (so that the global north is not dominant)
    - Representative of all sizes of organization and from all stages in the supply chain, public and private
    - Gender, age, ethnicity, background
2. Key tasks for the working group will include:
    - Define boundary conditions for any further investigation; in particular bearing in mind the seven values of the Movement and the imperative to 'Do no harm.'
    - Define the minimum set of user requirements for different sets of stakeholders, starting with the people in need whom we serve, and including donors, INGOs, NGOs, development partners and private sector partners.
    - Shortlist a set of financial options for set-up of a DLT platform and a sustainable operational model, given the foreseeable grant-funding environment and the learning from this research about other possible revenue models.
    - Explore whether how far an existing DLT might go to satisfying the requirements and what residual work would need to be done
    - Rigorous understanding of the legal and regulatory environment through engaging DLT law/regulation expertise
    - Establish a short- and long-term plan for design and execution of technical components, etc
    - Formalise a project team to design application and token tooling based on existing and potential developments
    - Define key roles, organisational structures (distributed or otherwise) for both governance committees and operational entity to support the platform

Towards the Next Generation Humanitarian Distributed Platform

These steps will build the foundation to establish the Next Generation Humanitarian Distributed Platform, and the movement to create a collaborative foundation for technical interventions that will help the world's most vulnerable people gain a foothold in the digital economy. As COVID and its economic fallout accelerates the demand for digital solutions, and as digital coverage progresses further, fuelled by both private and public sectors, **now is the time for the humanitarian sector to grasp the opportunity presented by this rapidly maturing technology, and to maximise its impact for the people we serve**.

APPENDICES

Appendix 1. METHODOLOGY AND STAKEHOLDERS

METHODOLOGY

This report was compiled by hiveonline Research[89], with support from the Danish Red Cross, and research subjects.

1. Desk review of literature, focusing on primary and secondary sources from 2017 to date, due to the emerging nature of the technology and recent adoption by the NGO and impact sectors.
2. Contributions of case studies by project participants and industry experts (special thanks to Dr Jane Thomason for generous permission to use research from her 2019 book "*Blockchain Technology for Global Social Change (Advances in Computer and Electrical Engineering)*"
3. Interviews with key stakeholders involved in blockchain and DLT projects for the impact and humanitarian sectors, including NGO teams, fintech startups, industry experts, academics, legal experts, big tech companies, financial institutions and others with an interest in the sector (interviewee list in the Appendix).
4. Three surveys of key stakeholders (respondent list below), some of whom were also interviewed.
5. Hiveonline sector expertise and previous research.

We have aimed to avoid survivor bias by including examples of failure as well as success. While it has been necessary to explain elements of the technology to elaborate on some points,

Selected industry experts, stakeholders and sponsors were then invited to review and comment.

The authors take full responsibility for all errors and omissions.

STAKEHOLDERS

The authors offer gratitude to all the survey respondents and interviewees who participated in the research. These are listed below:

SURVEY RESPONDENTS

Name	Affiliation	Name	Affiliation
Ezra Vazquez-D'Amico	BBB Wise Giving Alliance / GiveSafely.io	Jesus Pizarro	Heifer International
Christopher D. Freeman	BHN Inc. Basic Human Needs.	Franz Josef Allmayer	Hypha
Thomas Backlund	Blockie.org	Maria Mateo Iborra	IBISA
Héctor Linares	Blue Code Solutions	Catherine Fitzgibbon	Independent
Héctor Toledo Ballester	Blue Code Solutions	Imad Malhas	IrisGuard UK Ltd.
Morne Olivier	Business2Blockchain	James Lawton	Max Planck Digital Library
Julia Evelyn Larsen	CBS	Josh Hallwright	Oxfam

[89] hiveonline, hiveonline research

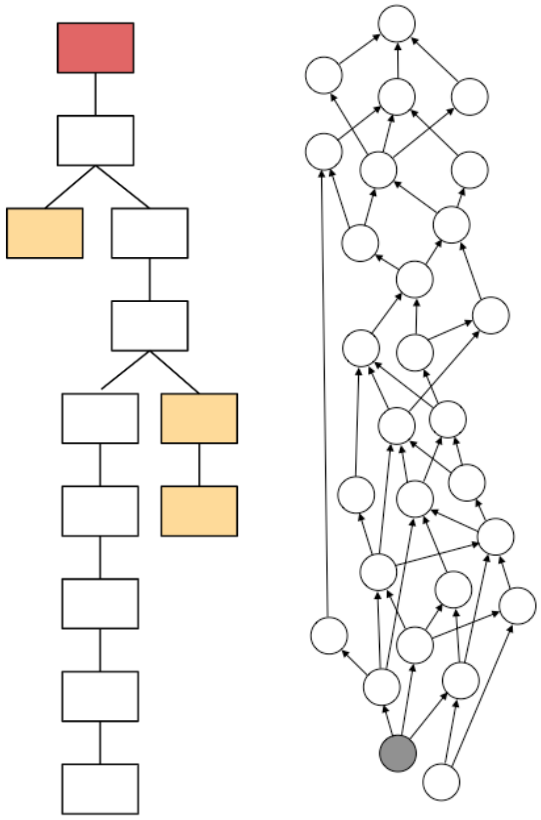
Name	Affiliation	Name	Affiliation
Miguel Prados	Comunitaria	Casper Niebe	PolloPollo
Christer Lænkholm	Dan Church Aid	Kelsie Nabben	RMIT University
Francois Sonnet	ElectriCChain	Shampa Bari	Sweden India Business Council
Robert Greenfield	Emerging Impact Group Corp.	Sorcha Mulligan	The SMEChain
Åsa Sundqvist	Filechain	Jason Curry	Tokonomics
Jane Thomason	Fintech.TV	Fritz Henglein	University of Copenhagen
Mark Laichena	GiveDirectly	Peter Zhou	World Bank
Andreas Papazidis	Graceaid.org.uk		

Interviewees

Name	Affiliation	Name	Affiliation
Jacopo Cecchi	Algorand	Susana Martin Belmonte	MedTown
Sean Lee	Algorand Foundation	Ric Shreves, Nick Meakin, Michael Warmington and Joseph Ubek	Mercy Corps
Adi Ben-Ari	Applied Blockchain	Stephan Meyer	MME
Elizabeth Mong	Ardor blockchain	Leila Toplic	NetHope
Ashish Gadnis	BanQu	Josh Hallwright	Oxfam
Dan Jones	Bext360	Casper Niebe and John McLoed	Pollo Pollo/Obyte
Jon Ramvi	Blockchangers	Isabel van Bemmelen	Progreso
Jeroen de Leijer, Hector Linares and Hector Toledo	Blue Code Solutions	Steve Box	Rare.org
Erin Taylor	Canela Group	Tomer Bariach	Seedbed
Sep Kamvar	Celo	Nick Williams	Sempo
Fritz Henglein	Denmark Technical University	Nick Gogerty	SolarCoin
Maarten Derksen	DOEN	Sorcha Mulligan	theSMEChain
Jane Thomason	FintechTV	Jason Curry	Tokonomics
Ezra Vazquez-D'Amico	GiveSafely.io	Ali Raheman	Trimark Technologies Ltd
Will Ruddick	Grassroots Economics	Nick Byrne	TypeHuman
Marianne Haahr	Green Digital Finance Alliance	Helen Disney	UnBlocked Events
Shona Tatchell	HaloTrade	Jamie Green	UNDP
Therese Marie Uppstrøm Pankratov	Innovation Norway	Kyriacos Koupparis and Gustav Stromfelt	WFP
Imad Malhas and Simon Reed	IrisGuard	Harish Natarajan and Matthew Saal	World Bank/IMF
Fennie Wong	Legal Specialist	Drew Propson and Sumedha Deshmukh	World Economic Forum
		Gareth Presch	World Health Innovation Summit

Appendix 2. What is Blockchain?

Figure 4: Blockchain and DAG structures



Distributed Ledger Technology (DLT), including blockchain, is a technical infrastructure that enables the creation of digital records, duplicated across many different devices (nodes), that are agreed to be true records by all nodes on the network, without centralised control. Trust is facilitated through a combination of encryption and digital signatures. DLT types include blockchain, DAGs (Directed Acyclic Graphs) and a number of other methods of data storage.

While it is easy to become baffled by the new terminologies associated with DLT it is worth bearing in mind the basic principle: it is a potentially universal means of ensuring trust and efficiency in transactions (financial or otherwise) without the need for intermediaries or centralised control.

The advantage of blockchain and DLT over traditional databases lies with the potential to democratise data control, creating a decentralized and transparent alternative to traditional data management. Put simply, data cannot be overwritten or altered once validated and consigned to the chain, removing the need for reconciliation checks and the risk of data loss. Blockchain-based records can provide full traceability of funds and other assets, even where trust between parties is low or non-existent.

Since the Bitcoin blockchain was described in 2009, blockchain technology has widely evolved and expanded. Major milestones include Ethereum's smart contract concept in 2013, R3 developed Corda for a consortium of banks in 2014 and Hyperledger Fabric in 2015, aimed at enterprise users. In parallel, many other DLTs have been proposed and developed, with ever evolving approaches to consensus protocols. To give an idea of the size of the ecosystem, in April 2020 there were approximately 5,400 cryptocurrencies being traded, each on its own blockchain, DAG or other DLT[90]. There are likely to be many more in development. Yet blockchain and DLT are not just limited to the creation and trade of cryptocurrencies. Today, blockchain supports a number of financial, academic and enterprise users in a wide variety of activities including transactions, identity, land registry, trade finance, bond issuance, supply chain, commodity authentication and many more.

The blockchain version of DLT builds "blocks" of transactions. Blocks are broadcast to the nodes on

[90] Rick Bagshaw and Coin Rivet, "Top 10 Cryptocurrencies by Market Capitalisation."

the network and a majority of the nodes must approve them. Each block is linked to the previous block through a cryptographic key and once validated, is broadcast to all nodes on the blockchain so that the whole record is on all the devices. In most blockchains, node operators (also known as miners) are incentivised to validate transactions through a reward of some of the blockchain's native cryptocurrency, and transaction fees. Bitcoin and Ethereum are both examples of traditional blockchains that rely on miners[91]. In humanitarian applications an NGO might choose to act as a node operator and would therefore be involved in the blockchain's cryptocurrency and transactions.

Blockchains and DLTs use "consensus protocols" to manage the validation process in a way that allows the network to agree on the state of the network and prevents "bad actors" from taking over. The earliest consensus protocol is "Proof of Work", which requires miners to solve a complex cryptography problem. As the technology evolved other consensus protocols have been developed such as "Proof of Stake", "Proof of Authority" and "Delegated Proof of Stake" [92]. The consensus protocol employed will affect the speed and cost of transactions, which actors have the most influence, and who can access the DLT, so is an important consideration when selecting a DLT platform.

A Directed Acyclic Graph (DAG) is an alternate DLT that links transactions rather than blocks of transactions. A DAG can have many paths or chains of transactions, several of which are valid. Hedera Hashgraph is an example of a distributed ledger that uses a DAG. Another key distinction between the various "flavours" of DLT systems relates to access and control of the network. Open, public/permission-less networks such as Bitcoin or Stellar are available to anyone, while private/permissioned networks such as Hyperledger Fabric and R3's Corda are restricted to invited or qualified entities.

In addition to data storage, some DLTs also offer a business logic layer, where instructions for operations can be written into the system. "Smart contract" functionality[93] allows for automation of business logic triggered by events. Smart contracts can be used for a variety of purposes including escrow, conditional payments, the creation of crypto tokens[94], as well as a number of blockchain based securities, stablecoins, non-fungible tokens and other use cases.

Appendix 3. Overview of DLT Consensus Protocols and Security

Several different approaches to DLT and blockchain have emerged, which have different advantages and are suitable for different use cases. This overview is not exhaustive, but is designed to explain the main differences without going into detail about the benefits, for the purpose of reference in this report.

Protocol	Brief summary/Example	Level of control	Throughput	Cost
Proof of Work	Blocks are mined by miners finding a value that generates hashes for transactions with e.g. leading zeros, forcing miners to	"Trustless", doesn't require any overarching	Slow, needs to be controlled to resolve finality (e.g. Bitcoin 10	High cost

[91] Though created with a traditional design relying on miners, at the time this report was written, Ethereum has been proposing a major change in architecture that would move the blockchain away from a traditional miners' model.

[92] Appendix 2 breaks down the different protocols

[93] Or other digital assets - see Appendix 5 for a breakdown of Smart Contracts and other digital asset types.

[94] such as the ERC-20 standard on Ethereum

Protocol	Brief summary/Example	Level of control	Throughput	Cost
	try a lot of different values and "work". They are rewarded with a transaction fee and a block mining fee. Example: Bitcoin, Ethereum	authority to guarantee actors	mins, Ether 15 seconds)	
Proof of Stake	Blocks are mined by a subset of stakeholders who have a holding in the currency, and are rewarded with a fee proportionate to their stake. Stakeholders do not have to use PoW because their holding guarantees they are incentivised to be good actors. Examples: Nxt, Ardor[95], Algorand[96]	Requires a holding, but anyone can join	Can be much faster than PoW although some PoS networks are controlled to discourage certain types of use	Low cost but requires a stake to vote
Delegated Proof of Stake	A delegated set of "supernodes" who can vote on new blocks in a round-robin motion, are voted in by token holders. Token holders can vote for multiple supernodes. Example: Ethereum Sidechain Fuse, EOS[97]	Requires a holding to vote, but anyone can join.	Much faster than PoW but tends towards centralisation due to low voter turnout and vote trading.	Low cost but requires a stake to vote
Proof of Authority	Instead of stake, leverages identity. Blocks and transactions are verified by a small number of pre-approved participants, who act as moderators of the system. Can be a round robin (AURA) or competition between a subset of authorities (Clique). Example: Ethereum Sidechains such as xDai; Hyperledger Fabric	Requires central body or consortium to pre-approve validators. Only for permissioned blockchains.	Much faster than PoW but tends towards centralisation due to low turnover of Authorities, can stagnate if Authorities become disengaged.	Low Cost transactions, high cost of implementation

Different Network Security approaches

BFT type	Brief Summary/Example	Applicability
pBFT	Practical Byzantine Fault Tolerance, where nodes are chosen in sequence - usually in combination with protocol such as PoA. Example: Hyperledger Fabric	Most secure in a private permissioned network but can operate in a large public network

[95] Jelurida, "Nxt: Decentralizing the Future."

[96] In Algorand, a new block is constructed in two phases. In the first phase, a single token is randomly selected, and its owner is the user who proposes the next block. In the second phase, 1000 tokens are selected among all tokens currently in the system. The owners of these 1000 tokens are selected to be part of a phase-2 committee, which approves the block proposed by the first user

[97] Binance Research, "Decentralisation, Governance and EOS - a Lost Case?"

FBFT[98]	In Federated BFT, all nodes vote on "quorum slices" of subsets of nodes on the fly, to act as authorities in an algorithmic POA or POS. Example: Stellar	Can operate in public or private network
ABFT	Tolerant of dropped signal, assumes that some messages may be lost or delayed. Nodes vote for "famous" nodes based on transaction throughput with near immediate finality. Example: Hedera Hashgraph (DAG)	Can operate in public or private network

Appendix 4. DLT Governance Examples

Stellar Foundation

Stellar Foundation[99] is governed by a Board of Directors, an Architecture Board and an Expansion Board in turn appointed by the three members of Stellar.org (Patrick Collison, David Mazieres, and Jed McCaleb). Institutions and organisations that use Stellar can become foundation Members, giving them voting rights. The Board of Directors is responsible for appointing the Executive Director, who is in turn responsible for employees of the non-profit enterprise. Stellar's decision making process is transparent, however engagement can be slow, impacting the speed of transformation.

Ethereum

Ethereum Foundation focuses on technical issues: Research (mainly Eth 2.0), eth Client, WASM, Whisper/Swarm, Pyevm/Trinity/Vyper, Solidity, Developer Tools and Grants[100]. Ethereum's operations are somewhat opaque, with a range of founders, however it demonstrates strong engagement with its largely technical user community. The lack of transparency of cost of operations and decision making process may contribute to some of the challenges encountered by NGOs.

Libra

The **Libra Association** is composed of a Governance Board and Technology Steering Committee and a Social Impact Advisory Board. The Association is made up of Fintechs, NGOs, Venture Capitalists, Consumer platforms and Facebook subsidiary Novi Financial. Association membership is capped at 100 organizations, each of whom makes a pledge of capital and operates a node upon which the Libra blockchain runs. In addition to the non-profit Libra Association, the Libra Payment Network is a separate incorporated entity formed to hold the licenses and act as the regulatory nexus for the payment network. The Association and the Libra Network divide responsibility for the Libra coins, KYC, and regulations (Libra Network) from the management of the underlying blockchain (the purview of the Libra Association). Libra is not yet operational.

Hedera Hashgraph

Hedera Hashgraph[101] is a public distributed network based on a DAG structure, aimed at enterprise applications, with a Governing Council of up to 39 (currently 15) term-limited organizations and enterprises, who are also node operators. These are mostly private companies or large corporations in consulting, technology, engineering and

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[98] BFT=Byzantine Fault Tolerance, a security structure used with trustless protocols that ensures bad actors can't take over a network without holding a majority of nodes. In BFT just under 33% of bad actors can be tolerated

[99] Stellar Development Foundation, "Stellar."

[100] Ethereum Foundation - NB Solidity is Ethereum's programming language for Smart Contracts, while other languages are Python spinoffs or other Javascript style languages. Ethereum 2.0 is the long awaited pivot/upgrade to Proof of Stake and other features.

[101] Hedera, "Hedera Hashgraph."

financial services but also include universities and, potentially, NGOs. Hedera's base consensus algorithm is patented to prevent forking but all other services on the network are open source.

Hyperledger

The Linux Foundation's Hyperledger Project comprises a variety of blockchains and associated technology donated by organisations including Fabric, Sawtooth and other chains. The Linux Foundation is a coalition of Business, Finance and Technology companies (large and small) with a Governing Board, Steering Committee, Marketing Committee and working groups. The structure and "open governance" approach is transparent, and although it is aimed at the corporate world, could provide a blueprint for other sectors.

Bloxberg

Bloxberg[102] is a chain dedicated to research institutions, governed by a consortium of those institutions, which in turn elects new members. An "iron throne" responsible for administration and organising an annual summit is also elected by members. Members are rewarded for participating in voting with greater voting rights, and this, together with the iron throne structure, will tend to concentrate control in a small group of the most active participants, which can work well for a special purpose chain like Bloxberg, keeping the focus on its core purpose. This is a reasonably typical structure across special purpose chains.

Decentralised Autonomous Association (DAA)[103] has been adopted by some blockchains as a legal framework for blockchain-based organisations or DAOs (Decentralised Autonomous Organisations), using a Swiss Association framework for non-profit organisations. It includes limited appointments and safeguards, together with guest appointments.

Appendix 5. Authors' Observations and Suggestions

While these do not form part of the overall recommendations, we have been asked to include the authors' perspectives on possible direction of the technology, based on our research and overview of the sector.

Given the need for sustainable, low-cost data movement and transactions, we would recommend a high throughput, algorithmic consensus protocol which minimises environmental impact and cost such as a PoS or dPoSm combined with a fast security structure. This could be a Blockchain based Federated Byzantine Agreement structure like Stellar's, which choses validators based on shards of the network, or a DAG based asynchronous Byzantine Fault Tolerant consensus like Hedera Hashgraph's protocol.

For optimal throughput, we recommend a DAG. We also recommend an open source, public platform, although we acknowledge that this presents risks of forking, which could impact interoperability.

Given the available options, which have been reviewed as part of the research, we have not identified an exact fit of DAG which also meets the governance recommendations, although Hedera Hashgraph is probably the closest, but falls down on open source and the fact that its governance committee is currently composed almost entirely of corporations. However, it also has the advantage of being able to integrate with tools built on Ethereum (in the Solidity language), which, as we've found, applies to many of the existing projects. So for expediency, the adoption

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[102] BloxBerg, "Bloxberg White Paper."

[103] Luka Müller et al., "Decentralized Autonomous Association (DAA) - MME - Blockchain."

of an interim solution such as Hedera would enable the rapid build of relevant tools, while using a robust, available network, as a proof of concept for further developments.

Appendix 6. GLOSSARY

Blockchain	Data structure in which blocks of transactions are cryptographically linked to previous blocks, to maintain the integrity of historic transactions
BFT	Byzantine Fault Tolerance - the property of overcoming the "Byzantine General" problem where individual actors have to agree without being aware of whether the information they have has been validated by others, or whether others are bad actors trying to game the system.
Bonding Curve	The mathematical description of the rising value of a cryptocurrency based on the increasing stake that users have put into the network. Used for crypto market making[104]; has also been used for community currencies.
CSO	Civil Society Organizations are non-State, not-for-profit, voluntary entities formed by people in the social sphere that are separate from the State and the market.
DAG	Directed Acyclic Graph - in which transactions are cryptographically linked to previous transactions in a mesh or chain of transactions, without forming blocks.
DAO	Decentralized Autonomous Organization - a non-hierarchical organisation governed by DLT based rules. In theory, a DAO could be run completely automatically. Has encountered challenges with the famous "The DAO" hack of 2016, which forced an Ethereum fork to correct, and a lack of user engagement for voting.
dApp	Decentralised Application - a mini application sitting on the blockchain, usually composed of multiple smart contracts, which operates without centralised authority.
Digital Asset	A Token, Coin or other digital representation of some sort of value, which can include: cryptocurrency or Protocol Token (the native currency of a blockchain), Stablecoin, Security Token (e.g. built on ERC20), Certificate of ownership, Certification, Ownership rights, "Digital Twin" of a physical good, and many other asset types. Non-fungible tokens are also available on Ethereum, designed to represent specific assets.
DeFi	DeFi, or Decentralised Finance, has recently emerged as a popular approach in blockchain circles, by offering traditional financial products such as payments, accounts, savings, insurance and investment over decentralised networks. They are typically composed of dApps and largely built over public blockchains, mostly Ethereum.
DLT	Distributed Ledger Technology, the technology that underpins blockchains and DAGs, which uses consensus protocols to ensure transactions are valid and protect from double spending or bad actors
ERC20	Ethereum's popular standard token structure, which has been used in most ICOs and other blockchain projects as the basis for a vast number of different digital assets. ERC20 has been certified by some regulators.
Fork	A Fork of a blockchain is a change in protocol or other rules, that creates a new "branch" of an existing blockchain, while the original branch persists. Rule changes can be to block sizes,

[104] Yos Riady, "Bonding Curves Explained," *Yos Riady* (blog), November 10, 2018, https://yos.io/2018/11/10/bonding-curves/.

	throughput or consensus protocols, or to address bugs or hacks (as in the Ethereum "The DAO" Fork). Bitcoin Cash is a Fork of Bitcoin.
Impact Business	Private sector business operating in the Impact sector, prioritising impact but aiming to be profitable.
NFT	Non-Fungible Token - these are special tokens that represent unique assets such as artwork, although their main application is in online gaming
NGO	Non-Governmental Organisation - this includes charities such as the Red Cross, Mercy Corps or Oxfam and knowledge organisations like the World Economic Forum, as well as smaller, local charities and knowledge organisations.
Node	A Node on a blockchain is a digital device such as a computer, server or phone, which stores a full copy of the blockchain. It can also be a validator, depending on the protocol.
Private	A Private (Permissioned) blockchain is one that is controlled by, and accessible to a limited number of actors, who can grant permission to other users to access the network, based on agreed rules.
Pruning	Some blockchains can be "pruned" to reduce this burden, removing non-critical information from nodes that want a lighter weight version.
Public	A Public (Permissionless) blockchain is one that anyone can access.
Sidechain	A Sidechain is a layer of protocols and/or smart contracts sitting over a blockchain, which provides different features such as Stablecoins and other digital assets, together with alternative protocols. Sidechains can feature "Merkle Trees" or tree structures of hashes to allow for fast processing of large data structures. Many sidechains have been built on Ethereum, including DAI, Fuse and xDAI.
Stablecoin	A digital asset (token) that maintains value, usually of a fiat currency such as the US dollar. Stablecoins are popular in financial services use cases because of their low volatility. They may be backed by a full escrow to avoid influencing the money supply, or by crypto assets, but are rarely issued without collateral backing
Smart Contract	A mini-programme that sits on the blockchain/DLT platform, that defines a set of conditions and the outcome when those conditions are met. Smart Contracts (Ethereum, Stellar, EOS, NEM, Waves, etc), Chain Code (Hyperledger), States (CORDA) or Autonomous Agents (Obyte) can confer or transfer ownership of digital assets, embedded in the application layer of a blockchain platform.
Social Enterprise	Private sector company with Social Impact agenda, often operating in collaboration with NGOs.
Token	A token is a special type of smart contract which defines a bundle of conditional rights assigned to the token holder. Tokens only exist in digital form, on the blockchain/DLT platform.
Validator (node)	A validator node is a node on the blockchain or DAG which participates in validating transactions. On a Proof of Work blockchain this could be any node with mining capabilities, while Proof of Stake requires holding of the cryptocurrency or other asset, and Poof of Authority selects named validators.
WFP	World Food Programme, a UN agency with a focus on tackling hunger.

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