



PRIMARY RESEARCH

Blockchain technology enabling sustainable development verification and approval

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Abstract

World corporations demonstrate good world citizenship responsibilities through their Corporate Social Responsibility Reports (CSRs) also referred to as World Citizenship Reports or Sustainability Reports). Most US S&P 500 corporations complete their annual CSRs. Two common methods of distribution of these CSRs have been through their websites and submission to Global Reporting Initiative (GRI); an independent international organization since 1997). The goal of a corporation's CSRs is to demonstrate how its operations are moving towards balancing environment, economics, and equity (or social justice)–commonly referred to as the 3 Es. CSR submission to GRI is voluntary and there is generally no independent verification and approval of the submitted CSR. Investors, shareholders, consumers, and government regulatory agencies are interested in the accuracy of corporations' sustainable operations data (energy efficiency, CO₂ emissions, recycling, fair wages, etc.). GRI has concerns about the accuracy of CSR data and is interested in verified data and reports. The emerging Blockchain technology offers some unique features that can be applied to verify and approve sustainability development methodologies and metrics of a corporation's operations as it relates to the 3 Es. GRI can be one of the partners in the process and thus enhancing the trustworthiness of the reports submitted. This research discusses how Blockchain features, such as, distributed database, members' verification and approval, security, etc., can enable sustainable development's data verification and accuracy. This can apply to public, private, and other non-business operations (e.g., non-profits). This research also discusses Blockchain technology applicability to supply chain operations (Business-to-Business), thus enabling sustainability effectiveness among businesses. There will be pros and cons during implementation of any new technology. This paper discusses some of these and projects what the future might look like using this technology for sustainability. Key areas of current implementations are also analyzed.

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INTRODUCTION

The rising concerns of inequality and climate change have brought some needed attention to the operations of corporations. They affect and impact modern age societies around the world since we live in a highly globalized world, and globalization has directly and indirectly affected both inequality and climate change (Dicken, 2007; Mutebi, 2018). The United Nations in its recognized study and publication on environment and development was key to the modern definition of sustainability (United Nations, 1987; Wahyu, 2018) focused on environment, economics, and equity (or social justice), also commonly referred to as the 3Es. Since the early 1990s corporations, governmental organi-

zations, and universities started to set policies and social movements to encourage and to set goals to balance the 3Es in their operations.

Corporation stakeholders including customers, shareholders, and communities are demanding that operations move towards a more sustainable operation (Amran & Ooi, 2014; Koroleva, Mierina, & Karklina, 2017). They also have been demanding transparency and governance. In order to address this issue of corporations being open on the 3Es and governance, an independent international organization was formed in 1997. The Global Reporting Initiative GRI was formed with the goal that corporations would submit their CSR voluntarily and those reports will be available to the

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public and other interested organizations. Today, GRI partners include the United Nations, Organization of Economic Cooperation and Development (OECD), and several others (GRI Strategic Partnerships). Most importantly, financial organizations have taken a great interest in evaluating world corporations for their sustainable operations and for the specially formed Exchange Traded Funds and Sustainability Index Funds. This is to meet the interest and demand of the investing public and other investment companies to support and encourage corporations to practice sustainable operations with the goal of balancing the 3Es.

CSR submissions to GRI are voluntary and they have recently developed some standards for submitting sustainability reports. There are no government requirements for sustainability report submissions like financial statements. There is also no independent auditing of the data submitted to GRI. This has resulted in some concerns on the accuracy of the submitted data in CSRs. This lack of verification for one of the most important aspects of a corporation's operation is a huge gap. Corporations might still be considering the CSRs as additional burden on them and some may see no return on investment. But this is changing with increased scrutiny by all the stakeholders today. Any additional process may also put a burden on GRI for verification of the data in the submitted reports.

This research paper proposes a model with the use of modern Blockchain technology that will enable data accuracy in the sustainability report submissions to GRI that is both efficient (from a cost point of view) and effective—corporations doing it right per the new standards set by GRI. The proposed model solution in this research paper will fill the gap of data verification for accuracy using Blockchain technology as the enabler.

Similar to financial submissions, the model proposes auditing of CSR report data using Blockchain technology in the cloud as a service. This approach will not put additional burdens on any one party and the cost can be shared by the corporations and the investment community. GRI can still make the reports available to consumers/public like they do now, but after all verifications and approval are done per the model process. Consumers are paying a premium for products that claim sustainability practices and they have a right to know the validity and accuracy of such claims. The proposed model provides that capability. More details on the technology background, proposed cloud model and other details follow.

Similar applications are being developed and in-progress in the healthcare space, mainly due to the advancements in Artificial Intelligence (AI). The ease of information availability

combined with recent AI research has created some powerful platforms in the healthcare industry using Blockchain technology. Today, patients do not have control over the access privileges to their medical information and cannot get the complete value of the inaccessible data. Blockchain and AI promises to accelerate research in this space and come up with some creative solutions that will enable patients with new tools to control and benefit from their personal medical data (Mamoshina et al., 2018).

LITERATURE REVIEW/RESEARCH GAP

The sections below describe the GRI's background and its existing standards. A brief explanation of Blockchain technology and a proposed model is also described to fill the data verification gap in today's process.

GRI Background

GRI is an independent international body, based in Amsterdam, Netherlands, that has pioneered sustainability reporting since 1997. GRI core members and community are the companies and organizations that support Economics, Environment, and Equity (or social justice), commonly known as 3Es of sustainability. Their overall goal is for a better managed world for all. The core members provide funding for GRI's operation and can put their GRI association and name to company products and services. This helps to further broaden sustainability participation, understanding, and required actions around the world by businesses and governments on issues of governance, climate change, human rights, etc., thus enabling a better living for all.

GRI's Vision and Mission are as follows:

Vision: A thriving global community that lifts humanity and enhances the resources on which all life depends.

Mission: To empower decisions that create social, environmental and economic benefits for everyone.

GRI has regional hubs all over the world developing a GRI community and is well recognized as a world class standard for Sustainability Reporting. The standards are made available free to the world public. The sustainability reporting is done by global corporations. GRI requirements are also recognized as the world standard for reports relating to the 3Es. Over the years, GRI has developed a range of partners around the world (companies and governments) supporting its vision and mission, and to provide greater transparency and accountability for the submitted reports. Some key leading strategic partners include UNGC (UN's Sustainable Development Goals, SDG), ISO International Standards for Business, Government and Society, and Alcoa Foundation (GRI Strategic Partnerships).

Over 90% of the largest 250 corporations in the world are submitting their sustainability reports to GRI. The current GRI's database has some 23,000 reports publicly available. There are now a new clear set of document requirements relating to the expected report data and format set by GRI and they are as follows (GRI and Sustainability Reporting Standards):

1 Universal Standards, namely: (a) GRI 101 Foundation, (b) GRI 102 General Disclosures and (c) Management Approach
2 Topic-Specific Standards, namely: (a) GRI 200 Economic, (b) GRDI 300 Environmental, and GRI 400 Social (referred to earlier as Equity).

It is to be noted that submitting sustainability reports to GRI is voluntary, although the report interest and value of the data content has been significantly increasing among public, company stakeholders, partners, and, most importantly, investors.

Investors Access and Interest in GRI Reports and their Accuracy

- One of the key users of the GRI reports' data is the financial investment community which is particularly interested in the various data, the accuracy, and the progress each company is making each year. Investment analysis companies, like Morning Star and Dow Jones, have their own company sustainable performance ratings for individual companies and for sustainability Index funds. The Morning Star Sustainability Rating is a reliable and objective way for investors to see how approximately 20,000 mutual funds and Exchange-Traded Funds (ETFs) are meeting Environmental, Social, and Corporate Governance (ESG) challenges (Morning Star). The Dow Jones Sustainability Index (DJSI) family tracks the stock performance of the world's leading companies in terms of economic, environmental, and social criteria DJSI. DJSI has a family of index funds for different elements of sustainability. The DJSI indexes the 2,500 biggest companies on the Dow Jones Global Total Stock Market Index. A Canadian study titled 'Do Investors Value Sustainability Report?' (Berthelot, Coulmont, & Serret, 2012) suggested that investors positively value sustainability reports and support the relevance of initiatives like GRI reports, UN Global Compact and ISO standards (Cheung, 2011). In a more recent study by European Corporate Governance Institute on the same topic, it was concluded that sustainability is viewed as positively predicting a company's future performance (Hartzmark & Sussman, 2019).

- Investors are looking closely to how companies perform as it relates to sustainability based on the ratings and index funds that result from the analysis done by companies like

Morning Star and DJSI. Most of the data for these analyses come from the reports submitted to GRI. This puts a significant burden on GRI to ensure that the submitted reports are accurate.

- In the current system of report submission to GRI, which is voluntary, there are no checks, or validation of the data being submitted, and relies purely on the integrity of the company itself. Financial reports of a company are audited for validity, accuracy, and standards. On the other hand, there are no checks or balances or any other auditing features on these very important sustainability reports submitted to GRI by independent organizations.

- Yale university, a leader in sustainability education and on sustainability reporting research, indicated the following, "Corporate disclosure on sustainability commitments and performance is increasingly common, but the extent to which this reporting can be trusted is largely unknown" (Yale University, 2018). The study continues to note the following:

- 90% of significant negative sustainability events were not disclosed in the reports.
- The current mechanisms that assure a corporate report on sustainability are not suited to sustainability.
- There are no universally mandated standards to describe sustainability topics (Most GRI standards are certainly an attempt to overcome this issue).

Given the increasing importance of multiple uses of the sustainability reports such as investor needs, company branding, and for public awareness, there needs to be a clear, consistent, and reliable process with knowledgeable partners involved in the process between corporations and GRI. Modern Blockchain technology can play a big part in bridging this gap to provide accuracy and help create a process easy enough for all parties involved. Some basic information regarding Blockchain technology will be described next and the actual proposal for implementation will be described in the next section.

Blockchain Technology Bridging the Gap

Blockchain technology gained recognition as a useful technology due to the bitcoin phenomenon which started in 2008 (Nakamoto, 2008). Since then it has been explored and used for various applications. IBM's definition of Blockchain technology is as follows: "Blockchain is a shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network" (Gupta, 2018). Following are some important characteristics of Blockchain technology (Cashman & Uhlig, 2019):

- Transaction Correctness: requests for data fit a well-

defined pattern of using encrypted sender identification, request type, monetary based information, and any third-parties.

- **Nonrepudiation:** given that the network is public, it is untrusted. The block data therefore necessitates a hard-to-compute mining operation, with its complementary easy-to-verify validation. Arbitrarily altering information and attempting to push a falsified block into the chain generally costs more than the benefit gained. This makes denial of a transaction unwieldy and highly expensive.
- **Audit tracking:** unlike many current computing systems, Blockscripts uses the public ledgers to ensure a constant audit tracking—the data itself in the chain is the audit trail.
- **External resources:** the entirety of Blockscripts' interface is public facing, using public nodes. Therefore, the system runs piggyback to existing infrastructure (Tar, 2018).
- **Scalability:** the scale of the network system is assured by being a distributed set of nodes that, while they do not trust each other, are certain to arrive at a consensus simply by statistics.
- **Capacity:** mining nodes need be only large enough to fit a working set of blocks in memory and others in any supporting storage mechanism. Compression techniques are

known for minimizing storage requirements of the chain (Towards Data Science, 2017) while preserving data integrity.

- **Availability:** the network is resilient, it is designed to support nodes dropping at any time and in any quantity, as long as users can access at least one node. Theoretically, one node could be the entire network system, although as the number of nodes decreases, the reliability of consensus drops proportionally.
- **Reliability:** given the nature of the multi-node network, no specific node need remain immediately consistent. Missed blocks, correct but not accepted blocks, too-long hash computations, or fraudulent blocks will be detected and corrected in an eventually consistent basis.
- **Data Integrity:** the nature of sealed blocks using checksums prevents fraud by making detection of single or multiple-bit changes obvious and is easily verified. The expense and unlikelihood of successful injection attacks of altered blocks is the primary deterrent of fraud (Nakamoto, 2008). It is more profitable to be honest.

Figure 1 and Figure 2 pictorially show the differences on how the database is decentralized and is immutable.

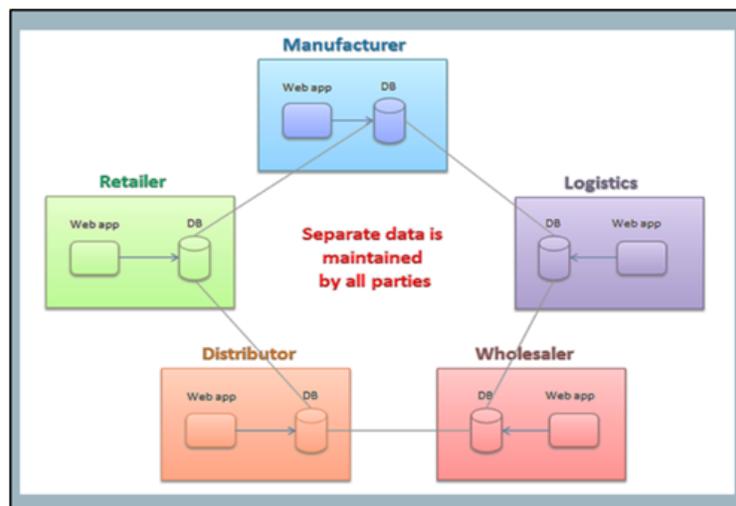


FIGURE 1. Multiple Databases, different and anyone can change (Sarfaz, 2017)

The Blockchain is an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value. It is a time-stamped series of immutable records of data that is managed by clusters of computers not owned by any single entity. Each of these blocks of data are secured and bound to each other using cryptographic principles (Tapscott & Tapscott, 2016).

This can be viewed as a list of records, called blocks that are linked using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data. It is designed so that the data contained in the Blockchain system cannot be modified and may be viewed as incorruptible.

Blockchain has no transaction cost. It is a simple way of passing information from source to destination in a completely safe manner. One party initiates the process by cre-

ating a block. This block is verified by thousands, perhaps millions of computers distributed around the net. The veri-

fied block is added to a chain, which is stored across the net, and viewed by the destination party. Blockchain creates a unique record (Tapscott & Tapscott, 2016).

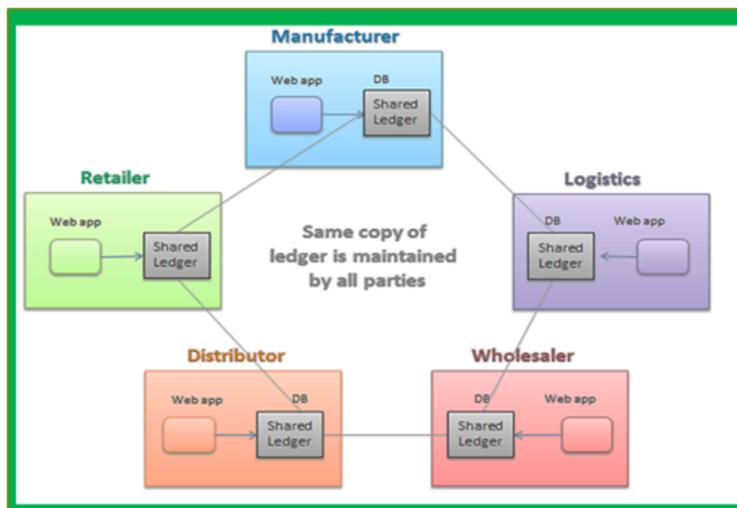


FIGURE 2. Distributed data, immutable for changes (Sarfarz, 2017).

Due to the inherent nature of decentralized data storage, this Blockchain technology provides a secure platform for storing data. Hence, if one node in the Blockchain network malfunctions or goes offline, other nodes in the network can be accessed for their persistent and accurate copies of the required data. This eliminates the risk associated with a data center, in regard to disaster recovery due to fires, earthquakes, etc., which could potentially lose or destroy the localized data. Storing data on a Blockchain also saves time. This savings in time for the client requesting the data can be significant. A typical request, processing, and access time of up to three weeks has been shown to be reduced to a turnaround time of one day, by using Blockchain technology (Cashman & Uhlig, 2019).

Blockchain technology provides network users with decentralized data storage, creating a significant increase in data protection and speed of recovery. Data stored in this redundant manner makes the entire system less prone to malice, natural disasters, and cyber-attacks. The encryption utilized in Blockchain allows a user to store sensitive or private information on the Blockchain, while giving it public access. This is accomplished without having concerns about third-parties improperly gaining viewing access to the stored information without having the proper private key. Lastly, the cost of data access could be reduced by automating the requesting process with Blockchain technology, thus freeing up human resources and their required interventions. Blockchain technology consists of a group of computers

(nodes) that are networked to each other over the Internet, and not linked to any single central server. Computers within this network work together to define and also agree on the shared state of data which they all individually hold. These computers adhere to the constraints put forth by the majority of the system which leads to strength-in-numbers for security of the data within the system (Lastovetska, 2019; Rosic, 2017). The shared state between the nodes can be viewed as a distributed state machine where every new block added to the network creates a change to the known and current shared state of the network. When a user accesses a network node, they will be unaware of the backend network supporting the Blockchain or any particular implementation details of the accessed node. Thus, when they make a request on the Blockchain they will access the network using an interface which is analogous to using a browser. Requests are sent to the node, bundled into predefined blocks, mining is performed, and if successful, a new block is created and linked into the existing chain. Duplicate blocks are arbitrated by the majority of the Blockchain network to determine which node is considered the winner. Winning nodes will collect all necessary information associated with the set of transactions within the new block (Rosic, 2017).

Basic Operation of Blockchain Technology: Some current Blockchain networks provide anonymity to all parties by providing one-time use access points for senders and receivers. This prevents discovering a particular party's iden-

tity and eliminates attack vectors. However, for publicly accessible data, this requirement is largely unnecessary. The benefit of using ids is that messages can be sent to mailboxes associated with the id so that system can implement event driven processing. Without the mailbox concept, there would remain some manual steps in handling requests, obviating the value of full automation.

Using these data, the user creates a transaction targeted to the Blockchain network. The user-initiated request is received by the system which will produce the result and send it to the interested third-party. The transaction is sent to some node in the Blockchain network, where it is built into a valid block. This block is broadcast to a subset of the network known to the node. Upon the block's acceptance at the various nodes, based on their consensus algorithms, it becomes a permanent public record. After the block is accepted, notifications of the block sequence number and transaction id is sent to the client and the client's inbox (Lastovetska, 2019; Rosic, 2017).

It is assumed that current organizations would need to re-tool some of their existing processes to handle Blockchain requests in an event-driven model from existing batch processing model; this is essential for the near real-time handling of these requests. Upon receipt of the request information (block number and transaction id), the system creates the required result. The block number and transaction id information contained within the record in its inbox determines the proper work flow and initiates the building or retrieval of the proper information for the client. Based on the recipients, the result is encrypted with the proper public keys, either supplied in the request or obtained from the party's registration record. The result is encrypted with the registered third party's public key which is obtained by requesting it from the Blockchain network. The Administrator builds a transaction request and adds the third party's id (recipient), the client id (interested party), and the encrypted information. Upon publishing and acceptance, the Blockchain network informs the recipient and all interested parties, details of the block and transaction id.

After the system has generated the result, it creates a new transaction per interested party containing the proper encrypted information and sends it out to the Blockchain network. Notification is sent back to the client's mailbox, updating the progress of the original request. The Blockchain network receives the transaction, and upon bundling in a new block and its approval, appends the block in the public record. Upon publishing and acceptance, the Blockchain network informs the recipient and all interested parties of the new block number and transaction id. The third party

receives notification in its inbox and requests the proper block from the Blockchain network. Based on the administrative details of the request, the third-party determines the proper processing action, retrieves the encrypted information from the block by its transaction id, decrypts it using its paired private key, and then forwards the transcript to the proper person or group. The information is now available to the third-party, bypassing much or all of the normal manual process.

Typically, within a network of mining nodes, different nodes compete to be the first to validate the information. Different strategies exist for generating proper hash values, the simplest is to increment it after each failed attempt. Another is to randomly pick values; other, more sophisticated approaches could be used, but the more sophisticated, the more time and compute intensive they become. Therefore, just about any node has a reasonable chance of being first to successfully compute the proper result. The first node to discover a correct value publishes the block along with its result. Other nodes will concede if they determine that the hash accurately describes the block and that it matches the network's specified pattern.

The technology has been reviewed by experts both for its advantage and some of the concerns mainly in the area of energy consumption in the area of mining for its bitcoin application. Bitcoin is an open access application with millions of participants. In the current proposal for use with data verification enabling for the sustainability reports, there will be a limited small number of permissioned users and the issue of energy consumption will not be an issue. Despite the many possible applications and benefits, it is important to note that block chain is still an experimental and evolving technology. It has big potential, but it is neither perfect nor universally applicable (Wigley, 2018).

RESEARCH METHOD-GRI PROPOSED IMPLEMENTATION

Large corporations can afford to have their own sustainability organization staff prepare both their CSRs (for publication on their websites) and GRI reports. GRI document submission are an extension of CSRs per the new GRI standards as noted earlier. Many other corporations without the expertise and/or staff, hire external consulting companies who specialize in sustainability report generation (both CSR and GRI reports). Consulting companies with similar skills also help corporations with certifications for ISO 14000, Marine Stewardship Council, Forest Stewardship, etc., all directly related to sustainability. These same or

similar organizations will be better suited to understand the GRI standards or requirements; they can help do research and generate GRI reports with all supporting documentation. Other consulting companies can be brought in for auditing the reports (although it is clear that the same company cannot do both for any given corporations).

The proposal below describes the parties involved and a process that enables and assures sustainability report data accuracy and approvals with the use of Blockchain technology.

- Sustainability certifiers, as noted earlier are consulting companies that understand the GRI standards; they work closely with the corporations, and can research and develop GRI reports per their required standards.

- Independent auditors – for finance, energy, emissions, etc., can offer their services for verification of the GRI submissions. Corporations themselves and/or investment companies (who follow sustainability corporations in their index funds or other sustainability related investments), should

be happy to pay for these auditors since this guarantees consistent quality and accuracy of the data.

- Blockchain, known for its smart-contract verification and approval mechanism, will help enable this process. We will be looking at a very similar process here for GRI submissions. For the purposes of using Blockchain verification and approval, GRI will need to put out a contract type of document for its various submission standards, one for each of the 100s to 400s series of document submissions.

- Research has also shown that 'Blockchain as a Service (BaaS)' is available, like Software as a Service (SaaS) (Tkatchuk, 2017). IBM is on the leading edge for this, already providing BaaS for the agriculture industry. Other companies, including KPMG, Oracle, Microsoft and Deloitte, provide BaaS. The service is provided on the cloud so there is no need for any special computing or data storage equipment to be bought by any party other than a regular desk top computer or laptop or other similar computing end device.

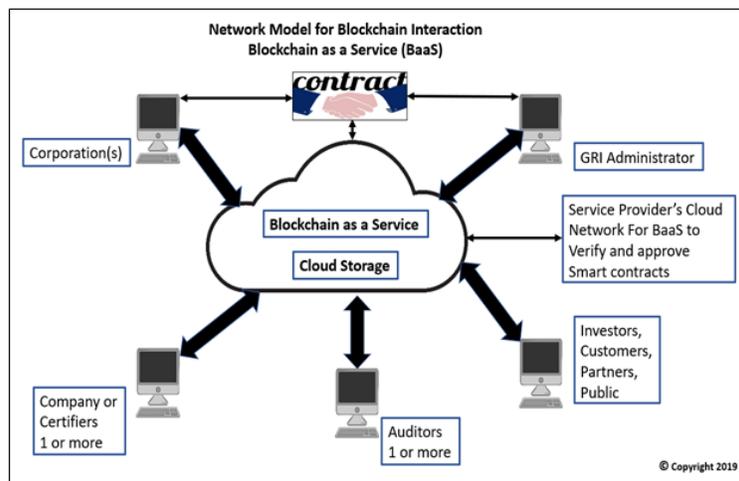


FIGURE 3. Baas model

Proposed Individual Record and Fields Content			
Transaction Record	Field	Content – Hashed Format	Comments
Field 1	Field 1	Pointer – Previous Record	Blockchain Requires this field for blocking
Field 2	Field 2	Login ID	Assigned Log In for Permissioned Parties
Field 3	Field 3	Account Type	Corporation, GRI, Certifier, Auditor, Investor, specific partner, etc.
Field 4	Field 4	Status	Initiated, In-Review, Approved, any other intermediate status per BaaS
Field 5	Field 5	Authority Level	Per BaaS, to submit docs, enter data, or reviewer, view only
Field 6	Field 6	Links to Approved Docs	All official docs created by the corporation or certifier in BaaS storage, reviewer can access and review
Fields 7,8,9	Field 7,8,9	Spare Fields	Reviewer, approved comments and others as needed by BaaS
Field 10	Field 10	Pointer – Next Record	Blockchain Requires this field for blocking

FIGURE 4. Record fields

In order not to put any new or additional technology burden on the GRI, they can outsource this service and, with cloud technology, can still make the verified sustainability submissions available on their website as they do now. In fact, this approach might reduce some or all the efforts that GRI puts into providing this service.

- The above process along with key certifiers and auditors fills the 'gap' that exists now (between the corporations and GRI) to confirm the accuracy of the data submitted to GRI.

- With this effective approach, investors, universities, and partners of GRI can provide their service with confidence that they can guarantee the accuracy of their reports.

Based on the key points made above, here are the proposed model diagrams showing how the process can work, includ-

ing the needed records for Blockchain formats and the approval interaction flows among the different parties.

Figure 3 shows the proposed network model, including how GRI can use a BaaS for the implementation. GRI will also have a smart contract published and agreed to by the corporations. The contract would clearly indicate the kinds of details needed for implementation. This can be done with the help of the BaaS service provider.

Figure 4 below shows a transaction record content and format. All the content is 'hashed' for security by BaaS.

Figure 5 below shows how BaaS will create the Blockchain once the permitted parties have verified and their status is set to full approved status.

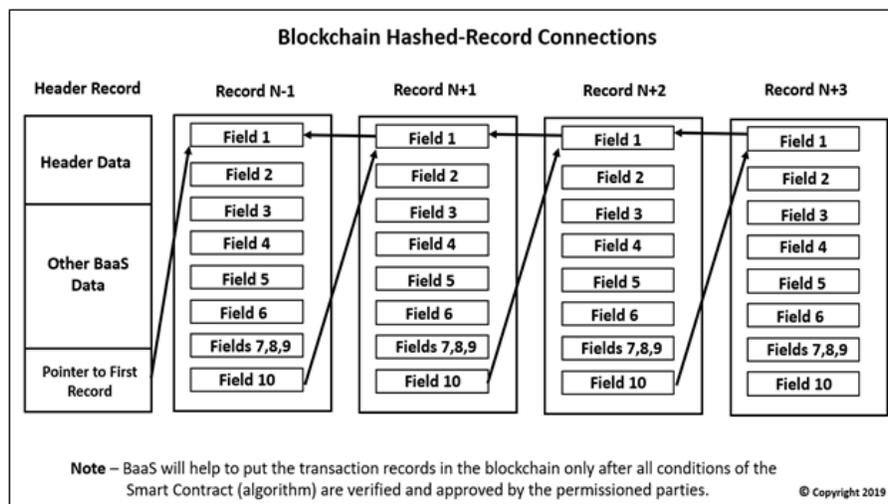


FIGURE 5. Blockchain hashed record interconnections

There are some misconceptions about the Blockchain technology due its heavy use in Bitcoin operation with millions of users, resulting in very high energy usage in mining. This and any related problems with millions of users does not exist in this proposed environment for CSR reports since this is a controlled environment with only permitted users – a very small and limited number (possibly up to 10 at a maximum). Once the reports are validated for accuracy and approved, GRI can post any and all appropriate materials on the website clearly indicating the technology enabled, audited and approved documents for public use on their website. GRI can also supply a more detailed report to the investor community or any other party. There can perhaps be a charge for this as well and those communities should be happy to pay for this.

USE CASE AND ACTIVITY DIAGRAM FOR GRI'S ENERGY REPORTING

Current GRI standards go across many requirements for sustainability report filings by corporations and they include the following (GRI and Sustainability Reporting Standards)

- 100 series, focusing on foundation, general disclosures and management approach
- 200 series, focusing on economics
- 300 series, focusing on environmental issues
- 400 series, focusing on social concerns

For the model proposed in this research, a specific GRI standard will be considered for Use-Case and Activity-Diagram discussion. GRI standard 300 series is about environmental concerns and the specific GRI 302-1 standard is for a corporation's energy usage/consumption within the organization. The standard addresses the Total Energy consumption within the organization as the net sum of the following:

- Non-renewable fuel consumed
- Renewable fuel consumed
- Electricity, heating, cooling, and steam purchased for consumption
- Self-generated electricity, heating, cooling, and steam
- Electricity, heating, cooling, and steam sold (this is subtracted for the total consumption).

Figure 6 below shows the proposed BaaS model, the different parties and the Blockchain assets involved working with the cloud of the BaaS service provider (i.e. smart contract, shared ledger, and the creation of block chain structure as each party completes their work input and the verification process shown with the sequence numbers.

The GRI and each specific corporation will need to complete a contract with the BaaS. GRI will give all the standards, formats, units of measure, etc. that cover all the standards. The three parties will agree on the specifics of the algorithm, all the specific IDs of the parties involved, including, certifiers, auditors, investors, customers, and partners and the details of public access. The algorithm will define the sequence and the specific item verification.

A simple use-case scenario walk through will be discussed. With Blockchain, the various network participants will interact as follows for GRI 302-1 standard. Each step below needs a digital signature and the creation of a hashed record (follow Figure 6):

1. GRI Administrator creates the initial record and popu-

lates the required corporation and other information for the first record entry for the 302-1 standard on a record created by the BaaS service provider (based on the smart contract). Initial concerned parties are notified.

2. The Corporation now updates the information authorizing the contract certification company for its part and this record is created and on approval of both GRI and the corporation, these two records are blocked, and all parties are notified.

3. The authorized energy contract certification company (which has the energy contract with the corporation) which has completed work and collected all the energy information as required by the GRI will input its data (along with any separate protected files with additional data, process, etc., per contract) in a record and submit this record. All parties are notified.

4. The Energy Auditor will now have full access to all the data (and all protected files from within BaaS cloud system) input by the contract certifier and will audit every item submitted for completeness to meet the GRI standards and the process by which each item was arrived at. This is verification by a registered energy auditor. The auditor will not sign off on the checking till all conditions of the contract and the GRI standards are met. On approval and digital sign off, a hashed record is created and is blocked with the other two. All parties are notified per Smart contract.

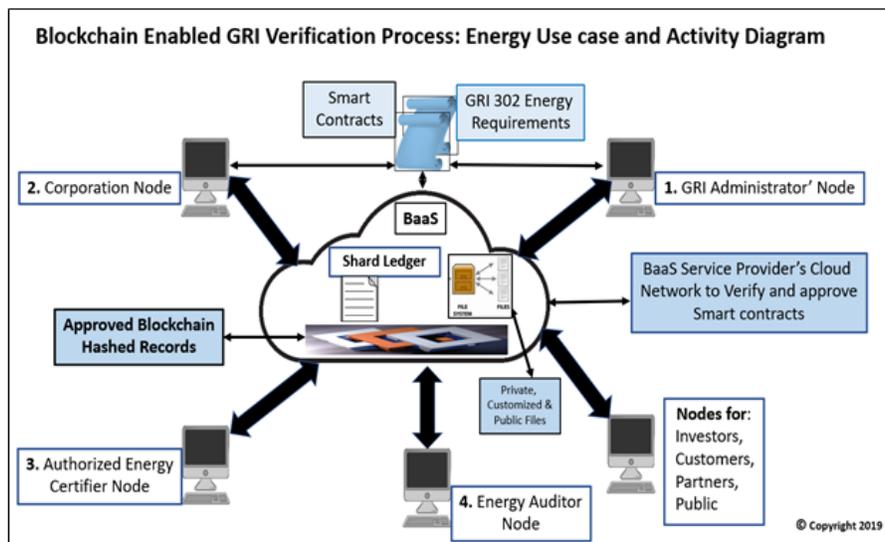


FIGURE 6. BaaS' energy case study activity diagram in the cloud

5. Now GRI Administrator comes back into the sequence (node 1, Figure 6) and can verify all the work and, upon meeting the smart contract requirement, will approve and sign off on the GRI302-1 submission of the corporation.

GRI's approval with its digital signature will be added to the Blockchain record.

GRI can now decide what further access it will give along with data to one or more parties in the box noted as 5 above.

The above is a simple demonstration of the algorithm and sequence at a high level. Similar algorithm and sequence would apply to other standards.

FINDINGS AND CONCLUSION

The voluntary generation of CSRs and other reports submitted to GRI clearly needs verification and approval for its trustworthiness and use by many interested parties – governments, civil society organizations, investors, and the public. GRI is now a world recognized renowned organization which provides a database where corporations can submit their CSRs on various aspects of their operations reflecting their balance of environment, economics, and equity (or social justice) concerns. Yet clear verification of the data and reports is a concern, and this is where Blockchain technology can be very effectively used for enabling verification and approval. This will bring a heightened trustworthiness for all concerned parties.

Blockchain technology is being adopted and implemented in many industrial sectors for its strong, breach-proof verification process by all concerned parties. Blockchain as a Service (BaaS) via cloud technology is being offered by hi-tech giants (e.g., IBM, Microsoft, Ethereum platform) which makes a service application implementation easier.

This research paper proposes an effective way that GRI can embrace Blockchain technology via BaaS by becoming a key partner with corporations in its implementation, using a smart-contract approach with permissioned partners. Other partners, including the UN and civil society organizations and the public, will be big beneficiaries. By taking the BaaS approach GRI and partners do not have to heavily invest in technology but will use seasoned cloud providers. Investors and corporations can be partners in any funding that might be needed to implement this technology with its strong future potential.

A survey by Tech Republic Premium measured the awareness, interest, and the extent to which technology professionals believe blockchain will impact business ([Tech Republic Premium, 2019](#)). The survey results showed an overwhelming majority (87%) of the respondents predicted a positive effect on business. Other business sectors related to sustainability can also immensely benefit from adoption of Blockchain technology. The Agriculture industry is showing big interest in adopting this technology as well. The future of Blockchain technology applications is to enable verification and approval of trustworthy contracts including those of GRI.

THEORETICAL AND PRACTITIONER IMPLICATIONS

Blockchain is an internet-based technology which has the unique capability to validate, record, and distribute transactions in ledgers. Initially, the technology was developed to support bitcoin transactions, in which, this Blockchain technology provided the means for creating and distributing the ledger, or record, of every bitcoin transaction to multiple computers interlinked on networks all over the world. Over the years, this technology has matured and is now capable of supporting applications in many spaces. In fact, as with many new technologies, application requirements have driven, and continue to drive, the enhancements of this technology. The potential of Blockchain to disrupt industrial sectors, commercial processes, governmental structures and economic systems seems to be enormous. It is suggested that the transformative power of block chain technology should not be seen as a threat to existing systems of governance; rather, it should be seen as an opportunity for national and international institutions to defend the rights of those they represent and to accelerate collective progress towards meeting the United Nations' Sustainable Development Goals ([Wigley, 2018](#)).

Having said that, it is important to keep in mind that block chain is still in an experimental stage and the technology is evolving. It has enormous potential, but it is neither perfect nor universally applicable or acceptable yet. Block chains are used to store information, in a different way than the traditional methods. The information is broken up and parcels are created. Also, these blocks' are not stored centrally, instead, each block is copied and distributed around an entire network, for ready access by individuals, institutions, NGOs, or businesses.

According to [Coindesk \(2017\)](#), over \$2.5 billion has been allocated to projects and companies working in the block chain industry ([Wigley, 2018](#)). In addition, academic institutions like MIT, Cornell, and the Digital Asset Research Lab at Imperial College are increasingly collaborating on open-source development. The decentralized, transparent, verifiable nature of the system means we can trust people and organizations precisely because trust is no longer an issue. The integrity of the system, of every participant, and of every transaction is determined by the network as a whole. Trust, like the information, has been distributed and secured. It is estimated that five billion people who are members of households are cut off from the financial system that most take for granted, walled off from the global economy. Block chains and the distributed ledger technology they employ are often most useful in situations where there is insufficient infrastructure or where there is no natural can-

didate for a trusted operator. We would see aid organizations able to receive funds instantly from many individual donors and then distribute these funds efficiently and effectively to people who can prove their identity without a piece of paper. We would see a world where anyone anywhere in the world can send payments to any country without any of them needing a bank account; where a consumer can verify the exact origin of their food; where voter fraud is minimized and citizens can have absolute faith in the democratic process; where anyone can prove what property they own, allowing for completely new types of capital formation and entrepreneurship. As per Bill Gates: *“We are living in a phenomenal age. If we can spend the early decades of the 21st century finding approaches that meet the needs of the poor in ways that generate profits and recognition for business, we will have found a sustainable way to reduce poverty in the world.”* (Wigley, 2018).

Following are a few noteworthy recent case studies demonstrating how the theoretical and practical aspects of this Blockchain technology are being used by practitioners, where the implications and results have been positive. 1 Fashion industry (Benedetto, 2019): One CEO, (Benedetto, 2019), using Blockchain technology based applications, is reducing waste in the Fashion Industry. The fashion industry is estimated to contribute up to 20% of industrial water pollution, in addition to millions of pounds of fabric waste. Benedetto (2019), CEO and co-founder of Queen of Raw, is trying to fix this problem. Her company uses Blockchain technology to reduce textile production. “The fashion industry is the No. 2 polluter in the world, and it contributes to the No. 1 polluter in the world,” (Benedetto, 2019) tells Here and Now’s Peter O’Dowd. “So it’s pretty bad, but where there’s bad, there is opportunity.” It takes 700 gallons of water to produce one t-shirt and another 700 gallons of water over its lifetime, (Benedetto, 2019) says. More than 2 billion shirts are sold around the world each year. “By 2025, two-thirds of the entire world’s population will face shortages of fresh water and be exposed to hazardous chemicals from textile production alone,” she says. “And one would think that it’s just in China and Vietnam and India, where we’re manufacturing, but this is actually having an impact on our water in Europe and in the United States as well.” “Blockchain technology is revolutionary for supply chain. It means that we are able to verify data and know at every single step of a really complicated supply chain, millions of people across the globe being connected as products move from place to place. We can now use Blockchain to verify data and know who said what when, who’s doing what when in that supply chain, and really in real time control the data and the

analytics. “An enterprise customer, or any of their vendors or suppliers in their supply chain, can verify data from an app on their phone, tell us what they’re doing with those fabrics. And for example, if they received 100,000 yards of fabric, but they only use 50,000 yards to make those t-shirts, they can click a button and an alert occurs, and now we know that there is unused fabric sitting at that location. 2 Altering the Apparel Industry - How the Blockchain Is Changing Fashion (Radocchia, 2018): In the past, a lack of transparency in a company’s supply chain could be seen as a competitive advantage. Businesses wanted to keep insight into their suppliers and manufacturers as opaque as possible. If no one knew where supplies were coming from, no one could build identical apparel. And this thinking extended to customers, out of sight meant out of mind when it came to worries about ethical sourcing and manufacturing in the fashion industry. It is clear there has been a shift in the way companies and consumers view transparency. Thanks to consumer trends and companies like Better Kinds that focus on decentralized manufacturing, it is now an advantage for everyone to know where your clothes come from. People are increasingly demanding transparency, while companies like Patagonia and Everlane tout sustainability and supply chain transparency as a selling point. The Blockchain solutions in the industry stem from its unique ability to create a physical-digital link between goods and their digital identities on a Blockchain. Often, a cryptographic seal or serial number acts as the physical identifier, linking back to the individual product’s “digital twin.” This link offers opportunities for a more transparent supply chain. Every time a product changes hands, that change in custody is recorded on the Blockchain. Counterfeit goods missing the physical-digital link are obvious, as are any attempts to divert goods. The chain of custody on Blockchain provides a record of the last party to gain custody of the product, showing where the counterfeit product slipped in—or the authentic product was diverted out. Greater transparency in supply chains will create new incentives for companies to change the way they do business and even how they view themselves as an organization.

3. KPMG International Cooperative (or simply KPMG). KPMG’s value-add approach (Ghosh, 2019): KPMG, standing for “Klynveld Peat Marwick Goerdeler”, is a multinational professional services network, and one of the Big Four accounting organizations, along with Deloitte, Ernst and Young (EY), and PricewaterhouseCoopers (PwC). As Blockchain moves beyond the hype towards effective implementation, it quickly becomes clear that the process involves more than just the technology. When solving busi-

ness challenges with Blockchain, companies need to account for the complex regulatory, tax, auditability, risk, and compliance implications that come with any global transaction platform. KPMG's value-add approach integrates financial management and digital transformation with industry proficiency to provide businesses with detailed guidance on Blockchain. KPMG helps clients develop Blockchain solutions from strategy to implementation. Seize the potential of Blockchain today with KPMG. Embracing a new technology that disrupts business as usual is not easy. To help clients make this transition, KPMG has dedicated Blockchain specialists across KPMG's core lines of business—Tax, Audit, Advisory, and Industries—in 30 countries across the world.

4. State in India to Release Policy for Blockchain and AI (Cant, 2019): The Indian state of Tamil Nadu is reportedly working on a state-level policy for Blockchain technology and AI. Tamil Nadu's Blockchain and AI policies are expected to establish ground rules on how the state government can apply the emerging technologies for service delivery and solving governance issues. Santosh Misra, CEO of the state's e-Governance Agency commented. "We are working on separate policies on Blockchain and AI. The AI policy is going to be perhaps the world's first policy addressing safe and ethical use of AI [...] No state or country has announced a standalone policy to address the safety and ethics associated with AI, and we have no precedence for it." Tamil Nadu is not the first Indian state to form policies and initiatives regarding Blockchain technology. Earlier this year, the Southern Indian state of Telangana released a draft Blockchain policy initiative, which aimed to establish an ecosystem for Blockchain startups and research institutes. In August, the second-largest state in India, Maharashtra, was well on its way to prepare a regulatory sandbox for testing Blockchain solutions across various applications. Containing the capital of Mumbai, and home to over 114 million people, the state aims to apply Blockchain technology in supply chains, agricultural marketing, vehicle registration, and document management. The government of Andhra Pradesh is reportedly exploring the use of Blockchain technology in its land ownership system to make it more transparent and fight corruption in the existing system, with an estimated \$700 million paid in bribes to land registrars across India.

LIMITATIONS

Blockchain technology is relatively new and not yet an answer to everything. Some real technically challenging areas still need to be resolved - technology, application use,

and many commonsense requirements. Following are some of the issues that should be kept in mind as the technology evolves.

Block Size

The chained blocks are of limited size and of specific application dependent formats. The size of these blocks are gradually increasing as the technology is used for more and more complex applications. To enable the handling of varied formats and sizes, Blockchain and data structures may need to be integrated as a step in the future. Duplication of these chained blocks may also pose a challenge, thus use of Big Data and centralized cloud based databases may need to be evaluated and integrated.

Scalability

The largest use of Blockchain today is the bitcoin operation. The number of users for this "sustainable development verification" application is still relatively very small – compared to enormous user bases like Visa, MasterCard credit cards, or any other real-time online transaction system. The technology needs to be scaled-up and enhanced to meet such massive concurrent use of client requirements. Blockchain is not yet a vast distributed computing system – it is based on duplication. This needs to be enhanced to use information distribution and parallel operations. The real-time requirements of massive user bases, concurrent operations, and minimum response time requirements are challenges of the near future.

Standards

Today, Blockchain lacks the kind of basic common and universal standards and protocols that made the Internet universally accessible (TCP-IP, HTML, etc.). As the technology matures and becomes more acceptable, standard protocols will guide the development of this technology. This is similar to many technologies in the past that have massive user bases, different platforms, and very strict compatibility requirements. Good examples of these are the internet, floating-point operations, communication protocols, wireless networks, etc. Some efforts in this area have started in the industry, and these need to continue and be formalized.

Divergent Interests

Blockchain is being evaluated and used in many divergent application spaces today. A one-size-fits-all paradigm will not be efficient as more application spaces and their specific requirements emerge. The current technology will need to be enhanced to enable users to optimize and fine-tune the implementation for their specific requirements and uses.

Blockchain Developers

Similar to other new technologies in the past, like Object Oriented Programming Systems (OOPS), Relational Databases Management Systems (RDBMS), etc., and new technologies of today, like Quantum Computing, qualified and dedicated developers are in demand for designing and

implementing these new diverse Blockchain-based applications with their specific requirements. This technology needs to be introduced and sequenced in academic curricula. Academia and industry need to work together to bring focus to this demand, and to train a qualified work force pool for our future needs.

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