Assessing Blockchain Potential in Healthcare Project Management through the Colony dApp

Abstract

This report contains an analysis of the Colony decentralized application (dApp) in the context of healthcare. Detailed use-case simulations, cost breakdowns, and competitive analyses were used to evaluate Colony's potential. The findings provide significant insight into the strengths and weaknesses of the Colony platform, as well as the challenges of blockchain implementation in the healthcare space as a whole.

Introduction

Prerequisites

For this article, basic familiarity with blockchain concepts is required.[1] See the terms sheet appendix for reference. It may also be useful to have a high level understanding of the Ethereum blockchain protocol.[2]

Acknowledgements

We would like to thank our project mentor, Abigail Sirus, for her assistance throughout the project as well as the research expert we interviewed, Tobias Hoppe, for providing subject matter expertise that was integral to our analysis. Special thanks to Jasper Ng for his early contributions to this project.

Purpose

Blockchain technology has long been touted as a revolutionary agent for the global marketplace.

However, deriving a true understanding of blockchain's value requires exploring its capabilities in regards to a specific industry. Our research group identified healthcare as a promising subfield due to 1) the complex set of stakeholders along both the patient and provider journeys and 2) the density and complexity of data as well as privacy regulations (e.g. GDPR, HIPAA). On a more practical note, the knowledge base of our IBM mentorship aligned well with clinical/pharmaceutical applications.

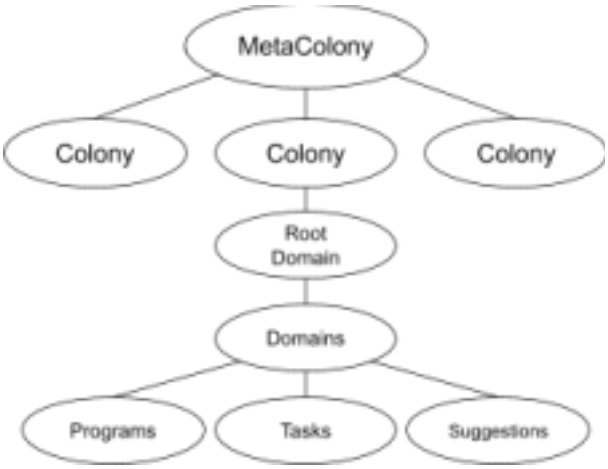
A core way that blockchain interfaces with industry is through decentralized applications (dApps). These platforms are built on a blockchain, and leverage the core tenets of the technology in ways that are distinct from the highly publicized financial applications.

Our team identified the Colony dApp as a promising candidate for deeper exploration. Colony's domain-based compartments and reputation subsystems seemed to hold significant potential for streamlining clinical workflows and robustly assessing performance among researchers/employees.

Over the course of our analysis, our team was able to gain a deeper appreciation of the capabilities, challenges, and ecosystems behind blockchain technology. We hope that this article will serve as an educational resource for both understanding the potential of a specific dApp as well as understanding how blockchain technology can be applied in a practical, industry-focused example across the phases of ideation to implementation.

Colony Background

The Colony dApp (“the dApp”) is a series of smart contracts built on top of the Ethereum blockchain. A beta version of the dApp is currently live on the Ethereum network. The dApp allows users to create and contribute to decentralized organizations called colonies. There is one main colony in the Colony protocol that handles development improvements, reputation calculations, network fees, setting up new colonies, and other general network maintenance that applies for every other colony. This MetaColony is currently administered by the Colony dApp team and operates like an open source project with involvement from the community for the Colony Network. All other colonies in the Colony Network are sub-colonies of the MetaColony.



A colony contains one or multiple domains, which can represent different teams, projects and departments, etc. The root domain is largely administrative and allows colonies to set user permissions. Tasks organize the work for colonies. A task is made up of a title, a description, a due date, a skill needed to complete the task, and the associated reward (bounty) for completing the task. Bounties can be in the form of Ethereum (ETH), DAI, or the ERC-20 tokens specific to a colony (native tokens).

In order to keep track of individual contributions to the colony over time, each user is associated with a reputation, much like in the real world. Whenever users complete a task, their reputations within a particular domain and skill will increase accordingly. Suggestions allow bottom-up contribution from the community and each suggestion can be upvoted by all members in the colony. Groups of tasks can be organized into Programs. A Program is a series of tasks that are broken into levels and there is an established order in which tasks have to be completed. When users complete all the tasks from a level in a program, they will earn a badge and can unlock the next level like a video game.

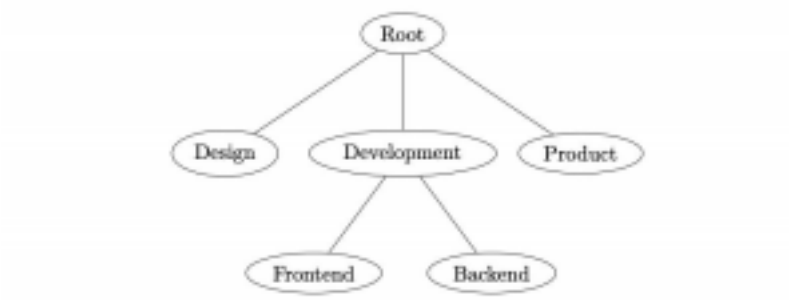


Figure 1: Parts of a domain hierarchy for a colony developing a web service.

Given the decentralized nature of the dApp, Colony allows for a more dynamic, fluid project management structure in organizations. One example of a software project in a colony can be visualized in Figure 1[3]. In particular, firms that wish to track a particular employee's or team's contributions and reward them accordingly are target

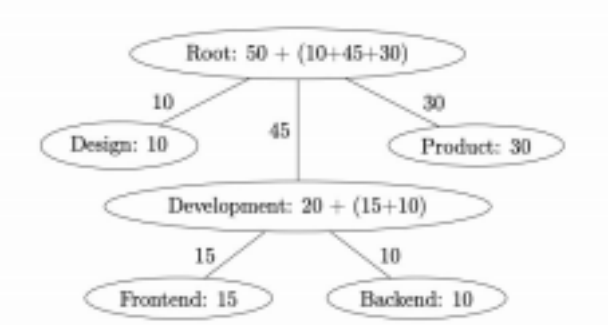


Figure 2: Reputation flowing up a domain hierarchy.

demographics for the Colony dApp. The built-in Colony reputation system, as shown in Figure 2[4], will aggregate a single user's reputation scores across all the subdomains they are active in so that the company can get a holistic understanding of what the employees have contributed and then reward them based on their aggregate reputations.

To gain a deeper understanding of the practical applications of the Colony dApp, we explored a clinical lab management use case.

Use Case Exploration: Clinical Lab Management on Colony

Selecting a Use Case

We came into this project looking for a way to integrate Colony into an existing organization to explore how blockchain tools may be adopted in the healthcare industry. Our team noticed that clinical data management (CDM) has complex processes and may benefit from traceability of contributions. We believed that the well-defined processes would allow us to more easily identify blockchain use cases. After exploring CDM, we broadened the use case to clinical lab management for large clinical research organizations.

Blockchain Potential in Clinical Lab Management

Our team identified time delays and operational inefficiencies in clinical lab management that could be improved with the use of blockchain tools.Time delays can be broken down into "internal" and "additional" factors.

Internal Factors

Internal changes in policy, data entry issues, and staffing were cited as key drivers of inefficiency.[5] Due to these problems, submission of institutional review board approval to begin a clinical study is delayed. Blockchain could potentially help this issue by maintaining an immutable record of the clinical data. We saw the potential for fluid staffing enabled by trust from blockchain to reduce internal time delays.

Additional Factors

Other issues are related to scale and scope. Coordinating work done at multiple sites was cited as a key issue.[6] Also, it is difficult for researchers to maintain regulatory compliance. The average team uses 27 different pieces of software during a clinical study to maintain compliance with regulatory bodies. In line with this, financial transparency is important when it comes to allowed versus billed charges. In all of these scenarios, blockchain, used appropriately, provides a measure of trust that could streamline operations significantly.

Colony Implementation

With the blockchain potential we found in clinical lab management, our hypothesis was that Colony was a viable supplemental tool. Not only does Colony allow for transparency in data management, but the dApp could also present a more streamlined process for CDM teams by allowing a more flexible staffing for each laboratory. It is under these perceived value add's that we came up with the following Colony implementation:

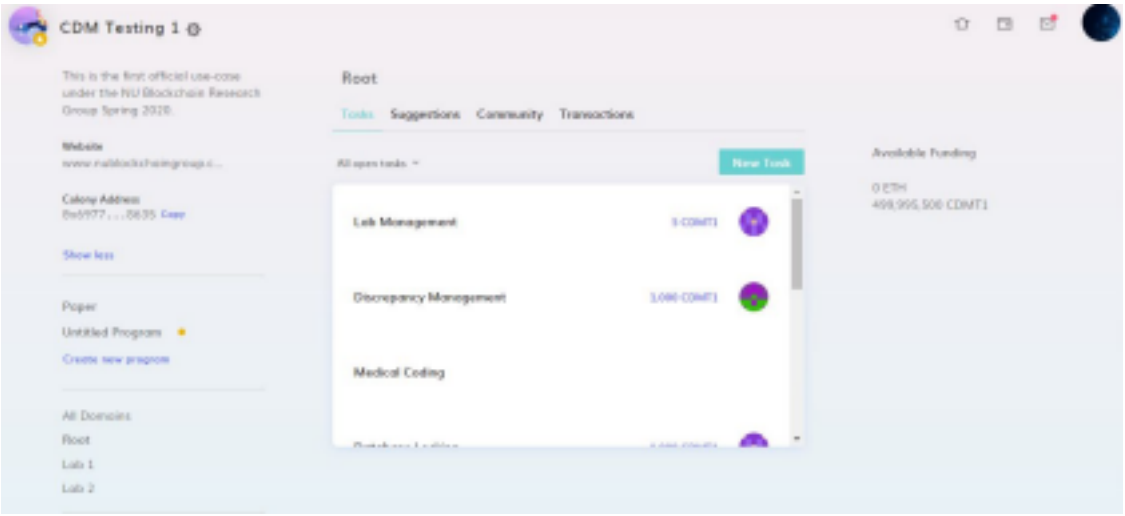


Figure 3. Interface of Colony Management over Lab & Root Domains as well as Task Overview

As seen on the left of Figure 3, each lab/working group within the organization would be assigned a domain within the Colony with lab managers authorizing tasks. Organization members with particular skills could complete bounties tied to critical lab related tasks across domains. These tasks could involve medical coding, data validation, and data entry among others; Figure 4 shows the interface of said tasks. Based on this implementation, we developed the following value-adds that Colony provides for lab management before interviewing experts in the research space.

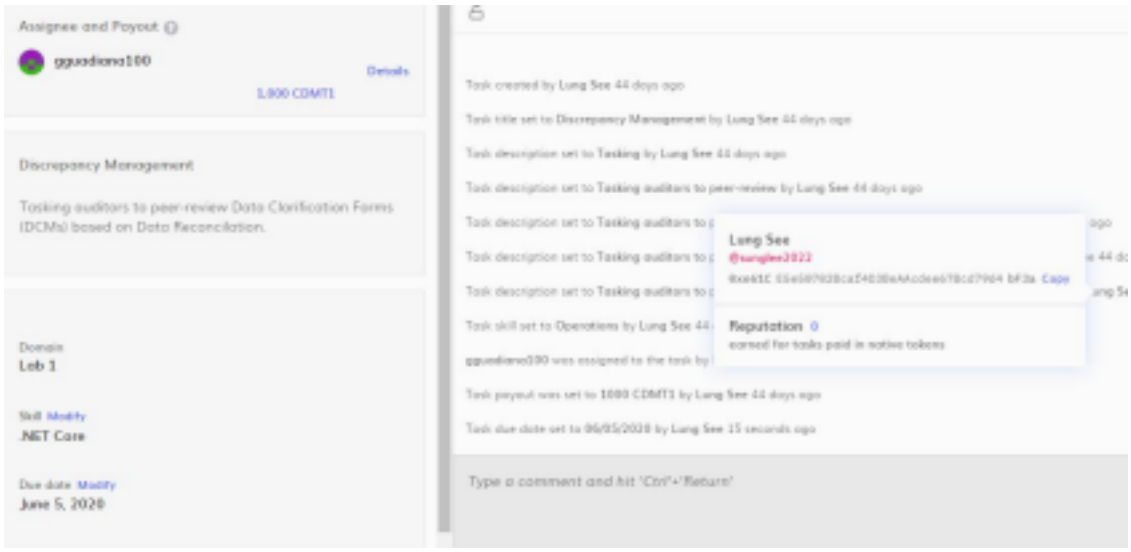


Figure 4. Sample Task for Discrepancy Management with Relevant Skills, Domain, Due Date, etc

Value-Adds and Thought Process -

Auditability

Using Colony for task management allows for an immutable audit trail describing who defined tasks, who did the work, and who evaluated the work done. This allows organizations to stay organized, keep staff accountable, and give recognition to value contributors in clinical projects.

We wanted to make sure that we used blockchain's auditability, and this was the first value add we explored.

Performance Metrics

The native tokens for the colony can be used as a way of measuring the value that someone contributed to the organization. Individuals acquire the native tokens by working on tasks, and these tasks have different payouts depending on the task's importance. The reputation gained for doing tasks gives a time-dependent indicator of the value that individuals provide to the organization. These are metrics that can be used for performance reviews as well as for improving organizational efficiency.

We were struggling with finding a way to make use of Colony's tokenization feature. We did not want the native tokens to have monetary value due to the traditional payroll system and tokens generally being considered a security. We wanted to use these tokens as a utility.

Trust

With there being a record of contribution and performance evaluations associated with this record, individuals would become more open to working on tasks from other projects.

We thought that individuals are incentivized to not collaborate on tasks outside of their main responsibilities when there is no structure for evaluating their efforts. We believed that without a better guarantee of their efforts being noticed, staff would be hesitant to work on other tasks even if it was to the benefit of the organization.

Flexible Staffing

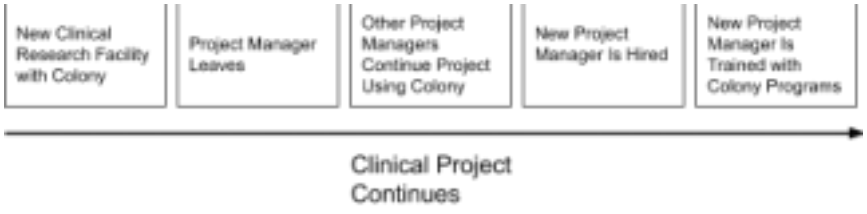
Employees may request or be assigned to work on tasks outside of their typical responsibilities. This enables greater collaboration between labs and can reduce time delays by shifting human resources when there are time-sensitive, costly tasks that need to be done. Also, this could lead to needing less staff.

We thought that organizations would value flexible staffing to improve the time delays that may occur in different stages of clinical research projects.

Trainings/Certificates

Colony programs consist of sequential tasks with different levels of achievement. Once an individual completes a program, they receive an indicator that shows their completion. These programs could be used for training staff or giving certificates. An example is using a Colony program to ensure that new medical coders have basic competency with their software through the use of task modules. With the digital identity on the rise, we believe that being able to prove and audit credentials of lab professionals in real time is a significant value-add.

<u>User Scenario</u>



A pharmaceutical company recently opened a new clinical research facility that uses Colony, with each lab having its own domain. Recently, a project manager unexpectedly left the company

during a clinical project. Other project managers use Colony to check the status of the project, evaluate work, and assign new tasks to continue the project without much delay. Staff members from other projects are assigned tasks on the project as needed, and Colony is used for project documentation.

A new project manager is hired. They work through a Colony training program teaching them how to use Colony and take over the ongoing project. Once done, the research labs resume normal operation. Afterwards, the company uses their colony specific token and the reputation feature to inform performance evaluations. The performance evaluators notice the extra output given by staff that helped the project while in its transition period.

Cost Case

All organizations need to project costs and plan their future for later budgetary review. By evaluating the cost case of implementing Colony into clinical lab management, we aimed to get insight into the scalability of operational expenses. We note that the task estimates used for each clinical research phase are rough estimates as it is difficult to estimate the tasks of individual clinical projects.

We made the following assumptions for our cost case:

1. The research organization has 3 labs—each within their own domain—that have one project manager and 10 staff members.
2. Every staff member uses the Colony dApp.
3. All ETH costs from using Colony used come from the costs associated around the date of

publication using the Colony Beta including the average mining fees at the time.

4. Costs associated with storage, broadband, and power will not be analyzed.
5. The 3 percent cryptocurrency token fee for using the Colony Network is not included.

The following items involve spending ETH while using the Colony dApp:

Startup costs:

- Creating a colony and native token
- Individual account setup
- Adding special permissions

Operational costs:

- Creating a task
- Evaluating a task

See Appendix A for the exact ETH costs for each item. We considered all costs with ETH prices at $220 USD/ETH and all time highs of $1.4 thousand USD/ETH.

We identified a quick project and a slow project. See Appendix A for information about the timelines associated with different phases of clinical projects and how we estimated the number of tasks for each phase.

PHASE:	Phase 0	Phase 1	Phase 2	Phase 3
Project Type	*Project Duration*			
Quick Project	3 months	6 months	6 months	1 year
`Slow Project	6 months	1 year	2 years	3 years

Total Annual Costs	**Quick Project**	**Slow Project**
$220 USD/ETH	$559.01	$3,557.35
$1.4k USD/ETH	$3791.20	$24,125.80

We then consider a “small organization” and a “medium-sized organization”, where the small organization has 3 slow projects and the medium-sized organization has 3 quick projects.

Colony costs for small organization per year

USD/ETH	Startup Cost	Operational Cost per Lab	Total Cost	Total Cost per Staff
$220 USD/ETH	$7.42	$559.01	$1,684.45	$51.04
$1.4k USD/ETH	$47.20	$3791.20	$11,420	$346.08

Colony costs for medium-sized organization per year

USD/ETH	Startup Cost	Operational Cost per Lab	Total Cost	Total Cost per Staff
$220 USD/ETH	$7.42	$3,557.35	$10,679.47	$323.62
$1.4k USD/ETH	$47.20	$24,125.80	$72,424.60	$2,194.69

The costs presented show that implementing Colony on a large scale may be costly and fluctuate

especially as the number of tasks change. Organizations must have a flexible budget and whether it is worth the cost. We note that the costs estimated using the all time high's of Ethereum likely overestimate costs due to the fluctuation in mining fees.

Comparison to Status Quo

Overall, Colony's functionalities and flexibility are rather limited compared with the tools currently used by the industry. First, as a dApp in its early developing phase, Colony can't be integrated with other tools like Microsoft Project with its MS suite applications and Atlassian with Slack and other inhouse softwares. This means that users in Colony have to import/export data manually and can't attach certain files to the task easily. Second, Colony is less customizable than other project management tools. For example, program admin in JIRA can add, remove and reorder fields and tabs in his screen to fit the way the team wants to work while in Colony the task structure and the dashboard can't be changed.

Third, Colony fails to visualize the work progress and display any analytical data of its user activity. There is no visualization or ranking of users' reputations in Colony so that it's hard for a

lab manager to do a performance review. Currently, there is only a list of task names in the main dashboard instead of a clear visualization of the content of the tasks. A centralized schedule with all tasks's due date and current status is also missing. In comparison, JIRA offers real-time KPI reports for internal use and Microsoft Project has a calendar with clear visualization of various tasks and their due dates. Trello also allows users to see a summary of the task and any file attached to the task in the dashboard right away without having to click into a specific task.

Lastly, unlike other project management softwares that have fixed subscription costs, Colony runs on Ethereum, a relatively new cryptocurrency that is subjected to wild fluctuations by its very nature. Indeed, while setting up the parameters for our user scenario and cost case as seen in the aforementioned pages, our research dictated a multitude of assumptions, including a relatively fixed ETH and gas value. Because research firms and corporations depend on long-term cost forecasts, this highly-variable pricing will dis-incentize many parties from immediately switching to Colony.

Possible Improvements

We therefore propose several possible improvements to reduce the gap between Colony and other softwares currently used in the industry. To facilitate a more efficient onboarding to Colony, APIs should be used to import tasks from other existing project management softwares. Colony should build a more customizable task structure so that it can fit into different types of tasks in a lab setting including data input, experiment, or clinical trial, etc. As the performance metric is a huge value add from the colony, the app should use clear visual metrics to display the ranking of users' reputations filtered by domains. It should also support queries for all the tasks completed by one user. These improvements will give lab managers significant insights for

performance reviews. Lastly, Colony could potentially adopt batched transactions of ETH to simplify the user experiences and improve usability of the app.

Expert Interview and Revisiting the Use Case

As indicated by the expert interview with Tobias Hoppe, the reality of these value-adds appear disjointed to what the industry actually demands. Despite our enthusiasm for blockchain-related solutions, the technology itself is not the "be-all-end-all" answer to bottlenecks but only part of the solution. Revisiting the value-adds, we have noted the following results:

1. Auditability

One observation that the healthcare expert pointed out was that auditability was absolutely critical to meeting industry standards and regulations. While blockchain technologies may revolutionize the way data is secured, Colony is not the right blockchain dApp for traceability. Undoubtedly, integrating blockchain solutions into healthcare will allow an immutable ledger to document all confidential data, but as a reminder from Mr. Hoppe, Colony is dedicated to decentralized task management—not data management.

2. Fluid Staffing

Initially, we hypothesized that enabling a more fluid staffing model would be a significant value add to data management, but the expert interview has indicated that flexible staffing is one of the least pressing issues in CDM. Moreover, leadership transitions are uncommon, but even then, constant documentation has enabled project leaders to resume work without interruption. As such, Colony does not add anything noteworthy to an already-met value add like fluid staffing.

3. Performance Metric

The reputation- and token-based framework of Colony is reputed to be substantial for evaluating individual contributions, but without built-in visualizations (graphs/plots/tables) or outputs that allow executive leaders to review these performance metrics, Colony falls rather short as a trust-based meritocracy. Therefore, while there exists clear benefits from Colony concerning audit trails, we have discovered that the value-adds provided Colony are inapplicable with the value-adds required from our use case.

Conclusion

Colony's Strengths, Weaknesses, Potential

It is our informed opinion that Colony's true potential lies in anonymous contributions, open-source projects and non-profit organizations. Indeed, Colony's vision is to build an organizational model that would replace the traditional management hierarchy with a bottom up decision-making mechanism.[7] This fits into the nature of projects that value community input and social good.[8] Open-source projects in healthcare industry like OpenMRS and WorldVistA could use Colony to attract more contributors and gather community inputs. In both cases, individuals with different skill sets can contribute to the project and earn reputations in those particular skills. Funding from the non-profit project could be given as bounties and thus provide incentives for contributions. Colony can also serve as a source for arbitration through associating voting power with the reputations, which would potentially reduce high coordination costs.

Yet as a dApp in its early development phase, Colony currently lacks flexibility and

functionalities to compete with other software tools. For example, Colony can't be integrated with other platforms and is less customizable than other project management tools. In addition, Colony fails to visualize the work progress and display any analytical data of its user activity. There is no visualization or ranking of users' reputations in Colony so that it's hard for project managers to do a performance review.

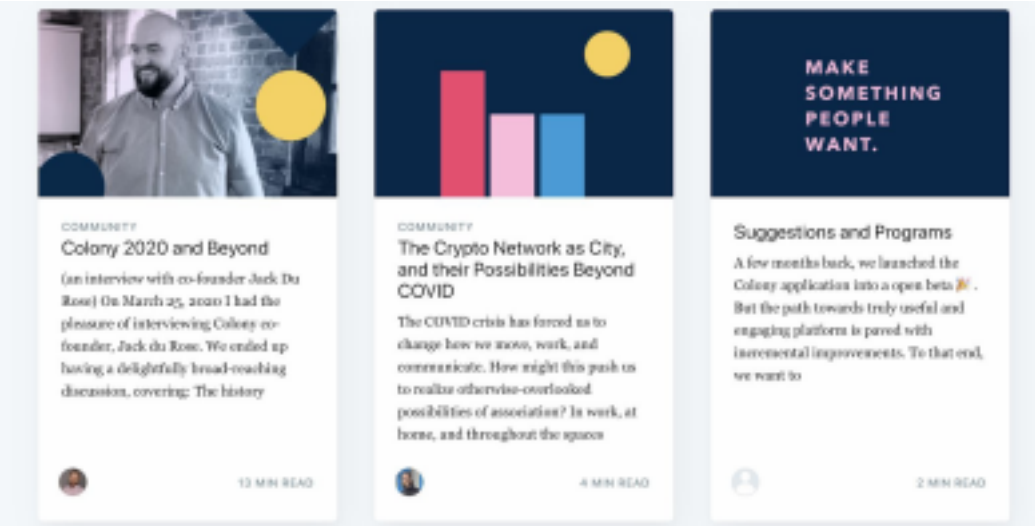


Figure 5 Blog posts about colony updates and improvements.[9]

Despite its limited features, Colony is making incremental improvements over time and moving towards a more engaging platform. For example, two new features were introduced this April, namely, Suggestion and Program, which is similar to the backlog in Kaplan used by Atlassian tools. In the future, Colony can adopt more community improvements in beta colony. Examples include a centralized schedule with all tasks's due date and current status, a reputation report for internal use and a more customizable interface. Those features will eventually place Colony on par with other software tools and convince open-source projects and non-profit organizations to adopt Colony in their daily operations.

Figure 6 Commit history of Colony network on Github.[10]

Realities of Implementing Blockchain Tools in Healthcare

In building out this use-case, we identified three realities to implementing blockchain tools in healthcare:

1. **Domain knowledge limits flexibility:** In clinical lab settings, most research specialists have a nuanced understanding of the project and research pipeline. Consequently, it is difficult to delegate tasks to third-parties without sacrificing efficiency.
2. **Accountability and auditability suffer with off-chain tasks**: Since most clinical and research work involves physical access to resources, developing a consistent data entry and validation mechanism is a significant challenge. In a similar sense, constructing verification processes that are non-digital provides additional layers of challenge to a blockchain implementation.
3. **Healthcare is slow-moving, and greater development of a decentralized ecosystem is needed:** Considering most health related data is stored on HIPPA-compliant health record databases, specific mechanisms need to be developed to interface. Additionally, most project management/oversight tools on the market today interact with a suite of add-ons

with varying degrees of functionality. These tools complement workstreams, and provide project managers with immense flexibility. The equivalents to these tools have not translated to decentralized applications, limiting their potential.

Potential of Blockchain Tools in Healthcare

Despite the limitations, blockchain tools have the potential to disrupt healthcare in the following ways:

1. **Auditability could be game-changing**: In a world where seminal research developments grant credit to a few individuals despite having many contributors, an immutable record could highlight the contributions of all parties and provide more equitable recognition and compensation.
2. **Crowd-sourcing capabilities and data could be effective under particular circumstances**: Projects that require large amounts of health data to be voluntarily contributed by participants could benefit from blockchain's systems of trust and authenticity. Additionally, research studies that are digital in nature and require talents in data analysis, software development, and media marketing could tokenize tasks and decentralize talent.

Appendix A: Cost Case Calculations

Colony Operations	Cost (ETH)
Creating a colony and native token	**0.0218** Pick the date, go back check the average gas price, and then based off gas price from the others that you redo, update the value
Individual account setup	0.000759286
Adding special permission	0.000744715
TOTAL STARTUP COSTS	0.033714715
Creating a Task	0.000744715
Evaluating a Task	0.000744715 - Task we checked on metamask = gas price * gas gas = gas fee / gas price Gas price = gas fee / gas
TOTAL OPERATIONAL COSTS	0.00148943

Table 1. Colony operations with their respective gas fees in ETH

Note: The costs in Table 1 all have a gas price of Gwei/gas and no fee was charged by the Colony Network since these costs come from the free beta.

Cost of USD/ETH	$220 USD/ETH	$1.4k USD/ETH
Startup Costs	= $220 USD/ETH * 0.033714715 ETH = $7.42	= $1.4k USD/ETH * 0.033714715 ETH = $47.20

Table 2. Startup costs for the cost case.

Estimating Tasks

We estimate the number of tasks by factoring the different stages of clinical research[11] and the amount of time associated with each phase.[12]

PHASE	**Phase 0**	**Phase 1**	**Phase 2**	**Phase 3**
Duration	Several months	Several months to a year	Several months to two years	One to three years

Phase 0 trials are generally small studies with 10-15 volunteers. There would be less staff involved at this stage, and we estimate there being 5 tasks per workday.

Phase 1 trials are generally studies that focus on whether the treatment is safe with 10 - 30 volunteers. There would be more staff involved at this point, and we estimate there being 10 tasks per workday.

Phase 2 trials are generally studies that focus on the effectiveness of the treatment with 25 - 100 patients. There would be more staff involved during this phase, and we estimate there being 30 tasks per workday.

Phase 3 trials are generally studies that assess long-term safety and effectiveness of the treatment with more patients, generally from 300 - 3000+. There are a lot more staff involved, so we estimate there being 60 tasks per workday.

PHASE	Phase 0	Phase 1	Phase 2	Phase 3
Tasks per Month	105	210	630	1260

Quick Project

Total Time: 27 months

Total Tasks: 20475

Average Tasks per Year: 1706 tasks

Slow Project

Total Time: 66 months

Total Tasks: 63630

Average Tasks per Year: 11570 tasks

Appendix B: Terms Sheet

● **blockchain** - a distributed, decentralized ledger

● **bounty** - a token reward for completing a task on Colony

● **CDM** - clinical data management

● **Colony** - an Ethereum community management decentralized application ● **Colony Network** - the network of colonies associated with Colony

● **colony** - a decentralized organization within the Colony dApp

● **dApp** - a decentralized application that runs on blockchain technology ● **domain** - a subset of a colony

● **ERC-20 token** - tokens created and hosted on the Ethereum blockchain ● **ETH -** the Ethereum protocol's cryptocurrency

● **Ethereum** - a blockchain featuring smart contract functionality

● **Gas** - a unit for computations on the Ethereum blockchain

● **Gas price** - the transaction price per computation paid to miners

● **GDPR** - General Data Protection Regulation

● **Gwei** - 10-18 ETH

● **HIPAA** - Health Insurance Portability and Accountability Act

● **native tokens** - tokens that are colony-specific

● **MetaColony** - the colony run by the Colony dApp team that governs the protocol ● **Program** - a structured set of tasks in a colony with levels and badges upon completion ● **smart contract** - a computer protocol that runs on blockchain technology ● **task** - the base unit of work in colonies

- **token** - a cryptocurrency asset

Appendix C: About Us

Organization:

Northwestern University Blockchain Group

Our vision is to foster a healthy and active ecosystem in Northwestern and Chicago, and solidify our community on the map as a strong hub for blockchain technology. Contact us.

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