BlockFrame CSU-P MJ Tracking Project Phase II

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Introduction

This report has been created for Colorado State University-Pueblo at the request of the Institute of Cannabis Research (ICR). It herein contains a summary of the work involved with Phase II of the Marijuana Blockchain tracking program. Inc. The basis of this project plan was to use the use case required by the State of Colorado and the Institute of Cannabis Research (ICR) for a solution to track and control the distribution of legally grown marijuana using blockchain distributed ledger technology. This technology is for tracking the existence of legally supplied instances of this controlled substance as it persists in the user community state wide. Tracking using a blockchain distributed ledger can securely store and transmit data to provide law enforcement the tools necessary for cannabis regulation.

This document outlines the Phase II work to expand previous limited use cases to show the scale of needs for tracking cannabis on the volumetric scale required for state wide adoption. Guidance and management for the project was provided by CSU-Pueblo Staff Dr. Yoanna Long along with subject matter expert training and technical direction from BlockFrame, Inc. Simulation test for volumetric scale of blockchain transactions were run in CSU-Pueblo lab under supervision of BlockFrame Inc.

Executive Summary

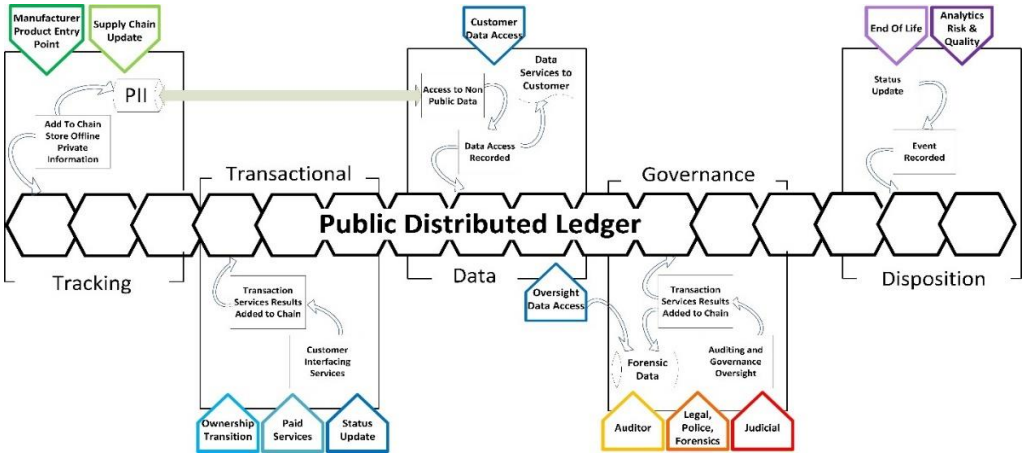
The second phase of the tracking project, commenced on May 26, 2018 and persisted through Jun 30, 2018 engaged CSU-Pueblo student participants Alex Marck, Jarred Horvat, CSU-Pueblo Staff Members Dr. Yoanna Long, Dr. Kuanyuan Huang, Dr. Rick Kosminski, and BlockFrame Inc. consultants, Mr. Tony Rossi Esq., and Mr. Christopher Gorog. Work began with and exploration phase to gain an understanding of the current tracking system used by Metrx for the tracking of cannabis throughout the grower production lifecycle. This portion determined the needed use cases and volumetric requirements associated with current and future operations.

The project successfully engaged the selected students with building an initial body of knowledge at CSU-Pueblo to determine adoption requirements of the initial blockchain project for statewide use in the enforcement of cannabis licensing. The results of this phase may be more important in relation to future work as the main production was a testing structure to implement a state-wide approximation of transactions related to the tracking of marijuana. The simulation scripts were designed to match the transactions of marijuana as related to the production of licensed growers for supply approximated to the scale which licensed product enters public distribution. Test results showed that the current limited implementation of Blockchain created in Phase I, was able to support the assessed number of transactions over time. However other aspects of the test displayed some side effects which may have to be evaluated further in later phases.

Technical Overview for Program

In researching the use cases for this program, participants evaluated the needs for the ICR to perform controlled substance tracking using distributed ledgers across the State of Colorado. The figure "BlockFrame Governance Platform" first introduced by BlockFrame Inc. in Phase I gives a high-level overview of what the end to end governance platform capabilities consist of and can be used for guidance in components of the current and future phases of the project.

Figure "BlockFrame Governance Platform"



In continuing on from Phase I of the project participants continued to build on the previous work to which utilized the IBM Hyperledger Fabric platform and outlined state-wide scale of transaction which would be required to reach full scale adoption for this use case. The results of this work and the capabilities of the platform will then be used to demonstrate scalability of the use case which can be utilized to support project funding.

Phase Description

The phase II will be implemented to further align the current use cases to the needs for cannabis tracking as it is done with current tracking systems. The effort will be in two main areas, which entail aligning the data needs for the content of a block to the industry needs, and implementing the insertion of blocks into the existing chain on a scale to match the needs for industry scale tracking. Results of this simulation testing will be proposed for publication in peer reviewed industry journals. Targeted Journals will include: Select call for papers from Association for Information Systems, IEEE, or other publication.

Research for Phase II

The plan for Phase II involved research in two areas: 1) determination of the current processes related to the magnitude of transactions related to the supply of cannabis in a typical producer environment, 2) scope of transactions related to the scale and dispersion of current licensed providers state-wide. Industry research for growers was done at The Pueblo West Organics which is a licensed distributer in Pueblo Colorado(Horvat, 2018). Industry research for government licensed providers was done by the ICR utilizing publicly available records from Colorado Department of Revenue. (Colorado Department of Revenue, 2018a, 2018b)

The industry research considered magnitude and types of transactions done by various types of licensed providers as discerned by typical industry operations. Industry observations provided typical numbers of daily activity for various departments associated with the internal processes of licensed growers, and handlers. Use cases analysis identified which types and the magnitude of transactions within the METRC application were related to the final release of product to consumer distribution. Industry analysis identified relative scale, expertise, sophistication, and accuracy related to varying industry providers to create a qualitative scale for approximating activities associated with human operations. Many rough calculations were relied upon due to the nature of this relatively non-technical industry which heavily relies on transient and unskilled labor.

The State licensing programs research garnered details related to the distribution of industry participants. Current licensing information showed industry hubs and hotspots for certain types of supply or handling activities. Licensing information also showed what the distributed transaction load would consist of and how distribution of participants may be affected by technology or communication limits in certain geographical regions or areas. The implementation of such a program for statewide adoption may have some of the largest challenges due to the nature of transaction endpoints and human limitation in lesser technical savvy regions.

Features and Dependencies

Dependencies for the current phase will be based on the limitation found in phase I and the performance or the platforms which the current phase I blockchain projects are operating on. Also, it was noted at the end of Phase I that the IBM Fabric platform had been augmented to an extent that the code of phase I required augmentation to work on the new versions. The rapid evolving nature of the selected IBM Fabric platform is also a consideration for dependency. The current phase will not include redesign to use the current IBM released code but will maintain the existing codebase and versioning which is aligned to operations of Phase I.

The features in this shortened Phase II departed from the initial plan as the timeline was shortened and the desire of this phase were determined to be to demonstrate the ability to scale the Phase I platform to full scale adoption.

can be seen in the following Figure Phase II Proposed Features. For this Phase students may use the data insert GUI developed in Phase I but changes or development on the GUI will not be a part of this phase. This phase will focus on the public blockchain and aligning it to be used for the overall material tracking use case. During this phase it is recommended that students interface with the ICR staff to determine the validity of the data model and get some actual sample data if possible for insertion and verification. The following five primary functionalities are determined to be the focus of Phase 2.

1) Alignment with ICR material tracking uniform data model. Understand the Current implementation of Metrc and use cases for tracking cannabis. Update base block format to match needs of the currently implemented use cases.
2) Augment Phase I platform and code to match the needs found in the use case matching in #1, and changes from fabric new product.
3) Create demonstration scripting to insert blocks into the Blockchain on a scale to match the use cases.
4) Produce a publication deliverable to match the findings and performance of the demonstration produced in this phase. Target peer reviewed publication for publication

Facilities and Resources

This Phase will be developed on top of the existing infrastructure from previous phases work and use common scripting environments to perform scale testing. Lab computers at CSU-P Lab RM 2XX will be used to simulate the remote distribution of end nodes across the state. Lab workstations will be temporarily configured to enabled continuously operations over a 24-hour period to simulate a single day of distributed operations. Scripts running on workstations will be designed to provide random transactions on many threads while recording the results of each independent thread into a separate log file.

Server for ICR will be used with Windows Server running a Virtual Box software containing Ubuntu Linux platform running the IBM Hyperledger Fabric created in phase one of the projects. The Virtual server will be configured to support continuous operations while monitoring all incoming transactions to the Hyperledger fabric and recording them to logging files along with timestamp and other transaction tracking metrics.

Research & Management

This phase will mainly consist of research conducted by students under direction of the management team. The determination of the ICR management team due to the limited duration of the project was to utilize the existing Phase I project and research how industry adoption and scaling would be impacted by the current configuration. Management of the project will be under the direction of the PI but rely heavily on BlockFrame Inc for implementation.

Roles and Resource management plan

BlockFrame Inc. offers project and program management resources with the global connections and affiliations of many partners. BlockFrame's continued oversight and involvement, with student training and implementation will maintain a conduit to keep the project on an industry leading track and maintain industry connections to support students with future employment.

Collaborations and Affiliations

BlockFrame Inc., maintains industry connections across the entire cyber security industry and especially in the blockchain field. Our affiliation with the state of Colorado, National Cybersecurity Center, Cyber Resilience Institute, National Research laboratories, and Industry Top Media gives us the ability to make connections for ICR and CSU-Pueblo and maintain this program in the spotlight statewide and industry wide. Continued collaboration on behalf of the university and blockchain program will be a valuable part of BlockFrame Inc's support.

Industry Use Case Collaboration

The two portions of research for Industry Use cases and Licensee distribution were connected to produce the results which are displayed in the Demonstration and Testing section.

For the Industry use case portion of research current procedures of a Licensed Colorado Producer environment were observed over a few months of operations. The use case for operations included the functional and progression found in figure "Phase II Industry Use Case". The use cases were the observed entry points for operations related to transactions into the current Industry tracking application Marijuana Enforcement Tracking Reporting Compliance (METRC)(METRC, 2016). The entry points for use case into METRC include four basic use cases at the industry licensee level, of these four several have downline or

dependent use cases which can be seen in the figure “Phase II Industry Use Case”. Several of the use cases have more relevant secondary updates which were determined to be more closely relevant to the needs for product as it enters the public distribution. In the process of tracking several progressive steps happen which are only dependent relevant to the internal grower’s operations.

For this poject the downstream operations in METRC which were identified with creating a packaged component were identified for mapping to transactions that result in CSU-P platform which the team has titled “Cannablock”. These block entries are displayed with red boarders in figure “Phase II Industry Use Case”. Each of these use cases also should be available from the data reporting capability which the State of Colorado has access to. Thus, the Cannablock can be entirely independent accessed and operated under the State of Colorado control independent from any industry collaboration.

Reports run from the State of Colorado Accessed reporting system can identify each entry related to the use case operations show with red boarders. The regularity of access to database records can be controlled by the state as desired with the largest impact concern being the timing and accuracy of entries from the METRC database to the blockchain ledger. The more often reporting is pulled and converted to blockchain entries, the closer the timestamp accuracy to actual METRC entry would be to blockchain forensic chain. The most desirable effect would be to poll in as close to real time as possible. If real time polling of the METRC database was implemented the only delay to real-time forensic chain would be cause by industry participant entry delays or network latency.

Figure: Phase II Industry Use Case

Transaction Use Case Data

The use case diagram displayed in figure "Phase II Industry Use Case" was created after interviews with employees who's job is to perform the tracking and compliance functions using METRC at the Licensee Colorado grower The Pueblo West Organics License # 404R-00107. (Colorado Department of Revenue, 2018c; METRC, 2016) The use case diagram shows the actor types and functionality done by the actors which result in entries to the METRC system(Horvat, 2018). It was determined that four (4) use cases initiated by employees at licensed marijuana production facilities, and one (1) use case performed by the Colorado Marijuana Enforcement Division (MED) would result in entries of value to Cannablock needs which would include transactions entered into the blockchain.

Two (2) use cases "create data" and "read data" have several variations which were more suitable for transactions related to the tracking need of the state of Colorado. Additionally, the use cases related to "delete" or to changes in employee status titled "Grant License for State" were also determined to be of value to statewide enforcement. You can see these operations which were determined that each should create a new blockchain transaction shown on figure "Phase II Industry Use Case" in addition to the addition of new facility from MED. The list of use operational cases determined for blockchain transaction entries include:

List: "Approximate Transactions Per Day"

1.	Create Package	160
2.	Create Manifest	32
3.	Accept/Deny Incoming	8
4.	Delete Drop	4
5.	Create/Drop	< 1
6.	Update Data	12
7.	Add License	N/A

Observation of our selected operation for this project demonstrated an approximate number of transactions for each of these type within an average work day. This information was evaluated related to the following criteria:

1. The number of each of these operations performed per day by the current operator/licensee,
2. Relative comparison of how many of each transaction was performed by this operator/licensee in comparison to other of the same type of transactions performed by other operator/licensees.
3. Access to METRC manifest serial numbers for all facilities could be discerned through relation to the numbers assigned at observed operator/licenses.

This was a very qualitative approach which for the most part was an assessment of employees who had immense experience with the METRC system.(Horvat, 2018) The process also assessed the scale and size of the observed operation, in relation to other growers in the state of Colorado. For this particular assessment it was determined that the size of the observed grower would rate a four (4) on a 1-10 scale of size in comparison to growers statewide. (Colorado Department of Revenue, 2018c; Horvat, 2018) The numbers in the list "Approximate Transactions Per Day" were produced as a result of this assessment.

State License Data

Reports downloaded from the State of Colorado MED showed the exact number of licensed operations for six (6) categories for which licenses are currently issued in the state(Colorado Department of Revenue, 2018a, 2018b). The license categories are issued for either medical product producer or recreational producers, and many operations such as the Pueblo West Organics which our team observed for this use case hold licenses in both categories.

In order to build a number of transactions for the state-wide use case once again a very qualitative process was used to determine approximate magnitudes of transaction on a statewide scale. The team determined that since the data on licensing was defined by zip code which that this correlated well and could be used to a determine a number of diversified end points. The breakdown for licenses showed that licensees were distributed over 132 different zip code regions across the state of Colorado. Also, breakdown of actual issuance showed that approximately 2,744 various facilities may be producing transactions that would then enter the system from different network locations.

Though the project did not have time or resources to verify each end point operation and licensee independently, the approximations made were most likely equivalent to expected transactions when normalized over the entire state. This analysis did not account for the different levels of varying internet networking technology which would factor into the disperse nature of network across any state-wide implementation. The ideal network conditions in the laboratory environment at Colorado State University Pueblo would have no method of accounting for such diverse network conditions.

Synthesis of Research Data

In order to build a number of transactions for the state-wide use case once again a very qualitative process was used to determine approximate magnitudes of transaction to model a statewide scale. The team determined that since the data on licensing was defined by zip code that this breakdown correlated well and could be used to a determine a number of diversified end points and transactions over a given 24 hour day.

It was also determined from interviews that different types of license holders would be responsible for various types of transactions, and some would perform more of one type vs. others which may not interface with the METRC system in the same manor (Horvat, 2018). Many license holders would also maintain redundant licenses in the medical and recreational segments (Horvat, 2018). The qualitative analysis performed attempted to cover the dynamic case to represent the majority of different transaction types related to the types of license holder which would perform such transactions.

Size of observed operation

In addition, due to the nature of varying size operations the qualitative process included a multiplier to show scale of a particular portion of transactions related qualitatively to size of operation. This assessment also related to the experience of workers which was mostly a result of the maturity of operations and/or the pool of skilled laborer's available in a given industry segment. This information as assessed and collected mostly by observation of related transactions visible globally within METRC.(Horvat, 2018)

The final results shown in the Figure "Number of Transactions Assessed for Pueblo West Organics" were in attempt to capture a relationship between each of the corresponding categories and a multiplier assessed to the industry operation observed for this evaluation. The number on multiplier related to the Pueblo West Organics operations, which is a rather large licensed operation in relation to others. Our qualitative assessment determined that the numbers seen on a day to day operation were about four times (4X) what the base would be per equivalent license holder in every category which they held license and participated in the related industry segment. Thus the base value assessed was one forth (1/4) the actual numbers determined for our observation partner.

Figure: "Number of Transaction Assessed for Pueblo West Organics"

zip	Numbers Shown for: Pueblo West Organics (License 403-01589)	blockchain transactions per day	multiplier	centers	cultivations	infused product	operators	testing	transporters	med total	stores	cultivations	product manufacture	operators	testing	transporters	retail total
XXXXX	Number of Licenses in Region			1	1	1	1	1	1	6	0	0	0	0	0	0	0
	Create Packages	40	4		160							0					
	Create Manifest	8	4			32							0				
	Accept/Deny Incoming	2	4						8							0	
	Delete Data	1	4					4							0		
	Create/Drop Employee	0.01	1				0.01							0			
	Update Data	3	4	12							0						
	Add Licenses	1	1														
	Totals			12	160	32	1	4	8	217	0	0	0	0	0	0	0

In the Figure "Number of Transactions Assessed for Pueblo West Organics" the applied a scale of size and multiplier is shown in the "multiplier" column. For this the Multiplier seen in the 4th Column is show based on a relative qualitative comparison to other providers in the state is about four (4) on a 1-10 scale of size. (Horvat, 2018)

Sie of average state-wide operations

The final portion of qualitative analysis was determined by taking the assessed value of Pueblo West Organics and creating a comparison of the base numbers derived to a scale over the entire statewide program. The final transaction set these numbers were assessed to state wide approximations are shown in figure "Number of Transactions Assessed Per Operator/Licensee."

The first part of this process was done to determine the number of transactions which relate to a particular type of licenses operation and divide between Medical and Recreational License. As with the assessment of one particular operation this approach was also very qualitative. The research and observation team assessed that particular types of license holders related to a few industry needs which did not relate to one operation performing in one category of license. In fact many of the examined operations held licenses in nearly all categories, and had operations don't by subcontractors and 3rd parties which made it even more difficult to make exact relation from license type to number of transaction.

The numbers show on Figure "Number of Transactions Assessed Per Operator/Licensee" it the results of many discussions and a very qualitative approach to several observed processes. As show it was determined that in relative relationships on the chart that different percentages of the overall transactions for a given category should be divided between multiple license categories. Examples of this can be seen in Create Package where 60% (96 of 160 transactions) were done is cultivation and 40% (64

of 160 transactions) were done in infused products(Horvat, 2018). Thus, the split between license holders when an operation only performed in one segment should be split 60% to cultivation and 40% to infused products.

Portion of transactions related to scale of segment operation state-wide was also another category which is accounted for in this final breakdown spreadsheet of which a single segment is shown in Figure "Number of Transactions Assessed Per Operator/Licensee". For this evaluation the multiplier column was utilized with the final numbers achieved for all other qualitative assessments to set the overall number of each type of transaction done statewide. Examples are shown in the multiplier of create package set to four (4) and Update date set to (5) while delete was set to one (1) and add license set to one (1) (Horvat, 2018). It is relatively obvious that many more packages are added and updated daily then the lessor number of changes made to the data added in create or update operations.

Figure: "Number of Transaction Assessed Per Operator/Licensee"

zip		Blockchain Transactions Per Day	Multiplier	centers	cultivation	infused product	operator	testing	transporte	med tota	stores	cultivation	product manufact	operators	testing	transporter	retail total					
XXXXX	Colorado Juristiction			2	1	1	1	1	1	7	1	1	1	1	1	1	6					
	Create Packages	40	4		96	64						0										
	Create Manifest	8	3						24				0									
	Accept/Deny Incomming	2	2	2.8		1.2					2.8		1.2			0						
	Delete Data	1	1	0.25	0.25	0.25	0.25				0.25	0.25	0.25	0.25								
	Create/Drop	0.01	1	0.01							0.01											
	Update Data	3	5		12	3						12	3									
	Add Liscenses	1	1																			
	Totals			6.12	108.25	68.45	0.25	0	24	0	3.06	12.25	4.45	0.25	0	0	Blk/Script	17	Scripts	13	Blocks	227.08

Overall the synthesis achieved a qualitatively approximation of transaction which could be applied to correlate the two sets of data. Produced a number of transactions related to a distributed number of endpoints which could be simulated with lab testing. The large spreadsheet of statewide license holders by region was then augmented as shown in Figure "Number of Transactions Assessed Per Operator/Licensee" to achieve a relationship between number of transactions by licenses to the number of license issued by the state of Colorado.

The numbers in the totals row for each of the regions across the state of Colorado were then summated to get qualitative totals for the numbers of endpoints across the state and then the number of transaction which would be generated by each one of those endpoints. This is show in the Figure "State-wide Approximation Test Numbers"

Figure "State-wide Approximation Test Numbers"

State Wide	Endpoints	2744	Transactions/Endpoint	3161	Transactions	109,646

Data for testing was assessed to be an overall number of transaction of 109,646 per day across the entire system state-wide. This would be divided into approximately 2,744 different computer systems distributed across the state. On average each system would need to send 3161 transactions in a single 24-hour period of time.

Demonstration & Testing

To demonstrate equivalent operation the team took the synthesis of the data based on the very qualitative methods and determined to utilize the overall number of the result category in place of exact numbers. For such it was determined that matching nearly the total number of transactions in a 24 hours period and distribute them from relatively an equivalent number of distributed endpoints would show an equivalent test for the scale of the statewide program.

The other determination for scale of testing was the facility and resources that were at the team's disposal. The research team was able to utilize the (HBS-119) lab at CSUP which contained 30 computer workstations on a Local Area Network. The team also had access to a new server which had been recently purchased for ICR operations and testing.

Test Equipment and Operational Configuration

The test was performed at Colorado State University Pueblo in the where the test team had use of the existing student lab environment. The server was set up on the same LAN as the classroom and the existing 100M network linked up and available.

Configuration of Test Environment

Server specs: Used a Windows server placed directly on the server housing the entire operations.

- Intel Xeon E3-1270 v5 @ 3.50GHz
- 32GB Ram
- OS: Windows Server 2012 R2 Datacenter (64-bit)

VM specs: Used VMware virtual machine running an instance of Ubuntu Linux which contained the Cannablock platform instance within the virtual machine.

- VMware Workstation Player v14.1.2
- VM RAM allocation16384 MB
- VM processor cores six (6)
- VM Hard drive allocation 30 GB
- Ubuntu version is 16.04

Cannablock Platform Specs: Used an IBM Hyperledger Fabric server, the server was running a single-peer, single-org instance of Fabric and that requests for transactions were handled through a custom RESTful Hyperledger Composer API that was programmed via Node.js.

- IBM Hyperledger Fabric version was 1.1
- IBM Composer API version was 0.19.7.

Lab workstations configuration: The workstations utilized scripts which would generate and send HTTP requests to the API, and the API would then create the transactions. The transactions were creating a single new participant in the Cannablock platform as the result of each transactions. This was done without an issuing identity for the participant.

- Windows 7 Operating systems
- Varying RAM and HD Sizes, none of which limited any test results
- Standard CSUP Image with Varying Software's on some machines

Test Environment

Test configuration focused on matching the number of tractions per 24 hr. period and a relatively equivalent number of distributed endpoints. The Blockchain instance which would field remote transaction was modeled on the ICR server which would handle transactions from many workstations within the CSUP lab. The number of endpoints at a particular region was modeled by the boundary of a single workstation running on a lab computer workstation. The number of randomly timed distributed transactions with in a region was then modeled by a unique script running on the lab work station.

A single script was created to randomly generate transactions which would be sent from the workstation computer to the server running the Cannablock instance. This single script would be run multiple times on the computer with the overall result of randomly timed transactions from independent threads sending transactions in a relatively equivalent scale that would be experienced from a state-wide distributed program. Exact scale of transaction would not be completely random over a 24-hour timeframe. They would have peak usage times and lesser use time which would align to human work day patterns. But it was determined that this approach would serve as an adequate, first base test and model normalized transactions over the entire scale of the state-wide program.

To implement a simplistic as possible test the scripts were set to run on twenty-two (22) lab workstations, and start one hundred (100) scripts, with fifty (50) random transactions over a 24-hour timeframe. With the timeframe allotted for testing and the use of the lab this proved to be a challenging enough test case, as it had to be run and re-run after making multiple configuration changes on several occasions. The figure "Implemented Test Numbers" shows the actual number of simulated transactions run to complete the test for the desired number of transactions to model the operation of this program over the entire state of Colorado.

Figure "Implemented Test Numbers"

Computers	22	Script/Computer	100	Transactions/Script	50	Transaction	110,000

Test One

The first test was not successful as operation of the workstations were set to disable after idle operation time by the operating system which forced the workstation computers at varying time frames to discontinue operations. After this test teams had to reset the lab environment and make changes to each machine to bypass administrative settings. Each of the machines had to be accessed with administrative permissions and make configuration changes. Some of the system contained unique settings or defects which were found and rendered removing a list of individual systems from the usable workstation test roster.

Test Two

The second test ran successfully for a period of time but was inconsistent as several machines had various software running on the machines which interfered with the test operation in several different ways. Much of the inconsistencies was a result of various anti-virous software's' running or different settings

related to security operation. Recovering and restarting after this attempt and determining which of the system would be able to be used. Again, some more of the system contained unique settings or defects which were found and rendered removing a list of individual systems from the usable workstation test roster.

Test Three

The onset of test three placed us in the current Test Environment defined at the first part of this section. As several of the lab workstations were not usable for one reason of another we ended up with the configuration of 22 usable machines for the test. Leading to the current number of scripts of 100 scripts per usable workstation with 50 transactions per script in the 24-hour period. This was a number which did not overwhelm the individual workstations by creating too many threads while producing a proportional number of endpoints which was qualitatively equivalent to the number of endpoints while matching the state-wide number of 110,000 transaction per day.

Test Results and Exceptions

Test results were a factor of the three test attempts and changes to equipment and software as the test progressed as discussed above. The final test was partially successful to the point where researchers were able to discern an approximation of the performance of our system in relation to the determined needs of the overall state-wide program. However, for the most part this test would also be considered a failure.

The information which was achieved from the test, showed the capabilities of the system and provided a data set for approximately half the 24-hour desired timeframe. Though further test may be run in the future, with the timeframe windows available we will consider that dataset adequate to assess the desired needs and intent of this phase. To continue further and achieve a complete 24-hour set of data would require complete recreation of the test environment to overcome the current test limiting roadblock. Further the results provided another level of insight which will change many underlying considerations for the foundation of the project.

Equivalent Scalability of the Platform for State-wide Operations

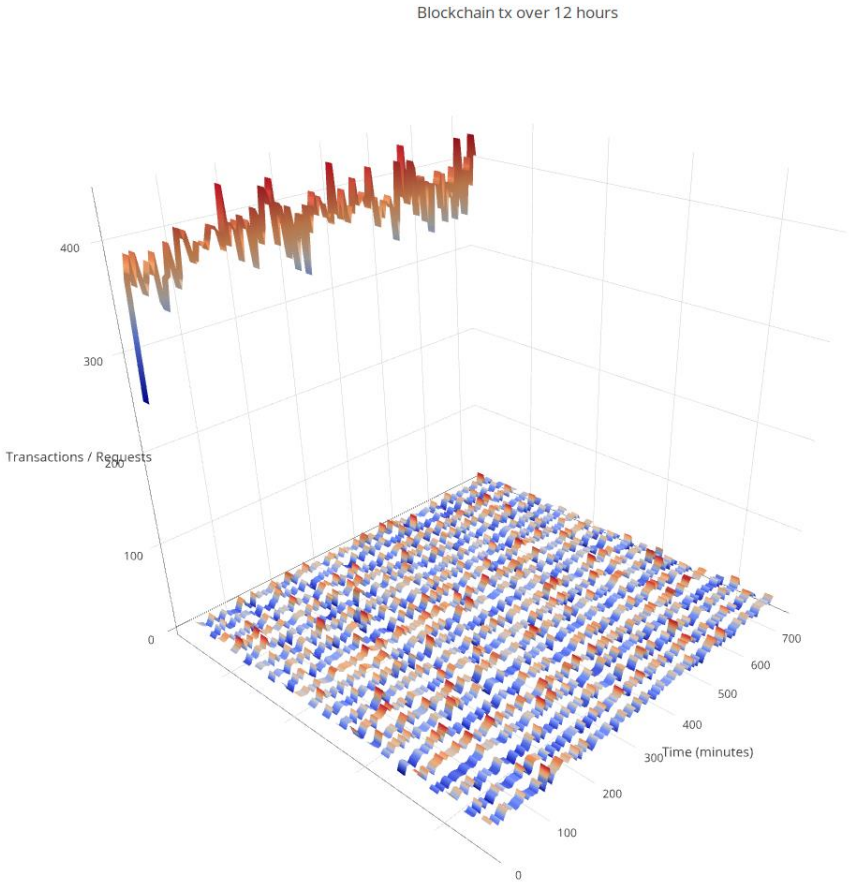
What the latest test three determined was the Cannablock capabilities for number of transactions over time in relationship to the needs of the overall program state-wide. The existing platform built on IBM Hyperledger Fabric proved adequate to handle a randomized transaction traffic of 110,000 equivalent to that which would be expected over a 24-hour period. The operation proved stable over the first 14 hours and data displayed shows the patterns over the first 12-hour period which corelates to half of the timeframe set in the initial set of parameters.

The Test Results

The results of output files on each of 100 scripts running on each of the 22 workstations were synthesized to show a full picture of the test. Though normalized over the period of operation by the randomness built into the scripts it shows a seamless operation capability of the Cannablock blockchain platform. For this process researchers collected the raw data from each of the 22 workstations and utilized Node.js script to read each log fil one at a time and would write the number of requests in each 5-minute period to a new file. They then used the paste command on Linux to create a CSV out of the 22 files. Finally research teams used plotly tool to compile the data in the viewable graphic format shown in figure “Ribbon Chart

of Test Three Results." At first glance observers can see that the largest limitation here is the nature of the ideal environment which the test was run in.

Figure "Ribbon Chart of Test Three Results"



Things which were not able to be modeled by the test displayed in Figure "Ribbon Chart of Test Three Results" were the nature of endpoint inconsistent, latency of network communications and varying technologies, the human nature of patterns related to daily routines, and many more that we could not anticipate in at this time.

Unexpected Results Resulting from Stress Testing

Test three stopped generating data at approximately 14 hours after the test begun. This was not a factor of the capabilities of the Cannablock platform, but a nature of environment parameters set using assumptions made by the research team. At approximately 14 hours of operation the Virtual machine housing the housed in VirtualBox on the Windows 2012 server, which run the version of Ubuntu Linux that contains the Cannablock platform reached it maximum capacity of size allotted for the virtual machine. This value was set to 30GB on the creation of the Virtual machine, which was an generalized assessment of the research team. It was assumed at the time of configuration that this size should be adequate for the desired scope of the testing. Thought not based on any reliable assessment the team did not believe that the Cannablock could generate so much operation space without extensive operation

time. During brief research into I possible problematic components the team examined some known issues which point to possible GoLevelDB was used as the state database instead of CouchDB could cause improved performance.(Thakkar, Nathan, & Balaji, n.d.) However timing did not permit experimenting with new configurations.

This assessment of size though grossly underestimate also shows a sanity check for the chosen infrastructure, as the growth of the platform excessively exceeded expectations of acceptable operation for such a platform. It was the assessment of the team then and still would be that this is an unacceptable usage of memory and would be extremely problematic for a rollout of the Cannablock statewide without drastic changes to the design.

Conclusion

It is apparent from the testing results of this phase of the Cannablock that the platform as designed would require some drastic evaluation of the internal operation of the platform. Thought the overall capabilities on a transaction per day timeframe would be able to handle a full scale state-wide rollout using the current configuration, the size of growth of the platform and internal memory usage of the Cannablock and possibly the IBM Hyperledger Fabric platform which it is build on would not work for an extended period of time at this growth rate of operating system memory.

If the use of operating system memory was linear to what was experienced in the first 14 hours of operation, which was seen at about 20GB per 12 hours of operation which would be 40-50 GB over a 24-hours period. This one statewide program rollout at these rates would show the need for 18+ TB per year on a state-wide rollout. Though our research did not do a full cost analysis, it is apparent to anyone who has been in technology for some time that this would be a technology limitation which needs to be evaluated more fully. As technology matures we look forward to revisiting these test results in light of the needs for this program and the State of Colorado.

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