Improving project monitoring and control performance using Blockchain technology [1]

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Abstract

Projects in the 21st century are becoming increasingly complex and require a monitoring, measuring, and control system that is dynamic to embrace the level of complexity present in most innovation projects today. It has become clear that to measure project performance accurately, project managers require tools and techniques that are very accurate in terms of measuring task performance to detect deviation considering the project plan and to take appropriate actions, when needed. The measuring and monitoring of the project is very critical because it informs the management intervention required, meanwhile project managers have to analyse the context of the deviation event and provide corrective actions required to taken and also the way the probability of the action of success. The centralization of project measurement, monitoring, and control in most capital intensive projects presence challenges like inaccurate reporting, over and under-representation of progress, and the use of different non-standardized measuring methods. In this study, we investigated how blockchain technology can be used to effectively measure, monitor, and control and manage complex project activities.

Blockchain is a system of recording information in a way that makes it difficult or impossible to change, hack, or cheat the system. This distributed, encrypted, immutable, time-stamped, and secure platform can assist the project manager to reduce project measuring; monitoring, and control costs while improving project overall efficiency. Blockchain will also assist to improve the monitoring measurement time performance by allowing every participant to update their progress in real-time without the need of a project coordinator ensuring that accountability resides at the bottom of the project work breakdown structure (WBS) and reducing measuring to control lead times. This paper shows how integrating blockchain technology in project management can dramatically improve the ability to plan and control projects.

Keywords: Project measurement and controls, blockchain technology, variation management

Introduction

According to the Standish group, less than a third of all projects were completed on time and budget over the past year. Hazır (2015-811) indicated that project measurement, monitoring, and control are also a major contributor to project failures. Asharaf and Adarsh (2017-45) specified that blockchain technology known as a platform that introduced cryptocurrency like

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bitcoin, where the technology warrants speedy, secure, identity-protected transactions with its distributed or decentralized arrangement. Niebecker, Eager and Kubitza (2008-145) directed that these technology-based characteristics can solve a lot of technical problems. In project measurement, monitoring, and control, project managers can make it useful for handling other types of transactions, including sending reports, sharing information, handling payments, ensuring completion of tasks, and much more. Saberi, Kouhizadeh, Sarkis and Shen (2019-2121) showed that blockchain capability of being a trustworthy distributed ledger makes it suitable for each work breakdown structure (WBS) traceability and fulfillment of its validation test. Barreto and Rocha (2010-443) directed that it can also be a useful tool to manage project stakeholders using the RACI (responsible, accountable, consulted, and informed) framework as a source of trustworthy real-time information.

Research hypothesis

The following are research hypotheses:

1. Blockchain technology will improve project monitoring and control performance which will allow traditional project systems such as EVA to improve accuracy

2. Blockchain technology will provide project real-time data by placing accountability to the lowest level of the work breakdown structure (WBS) which will generally improve the performance of the project management office (PMO)

Variation management in projects

Aziz (2013-54) thought that clearly defining the relationships between tasks and the project end date by using buffers while utilizing statistical process control is a common practice by most project management techniques such as critical chain project management (CCPM), critical path method (CPM) and project evaluation and review technique's (PERT). Arain and Pheng (2007-84) understood that many project managers are well aware of the problems associated with schedule and cost risk, but what they probably do not realize is that they are mostly not dealing with risk at all, but a variation. Jawad, Abdulkader and Ali (2009-178) indicated that, the concept of process variations is more understood by manufacturing process professionals who can assist project managers because they have been dealing with process variation since manufacturing began five thousand years ago. De Meyer, Loch and Pich (2002-60) believed that project management practices and theory assume a deterministic approach to management which does not reflect the probabilistic reality faced of dealing with everyday events. Aziz (2013-56) alleged that a project task is a special kind of process that takes place in the context of a project. According to Jawad, Abdulkader and Ali (2009-180), there are two types of variations: special causes and common causes:

- Special causes - factors identified as direct causal agents of variation and that you can control by correcting or eliminating the cause. According to De Meyer, Loch and Pich

(2002-59), in software projects, special causes are things like lack of effective requirements elicitation, tool defects, immature technologies, and so on.

- Common causes - latent or uncontrollable factors that perturb the system; thus, common causes are not controllable through correction or elimination of the cause. Arain and Pheng (2007-82) indicated that we either do not know the cause, or we cannot control it. Common causes are relative to the state of the art of the process, which includes the technology, the level of automation, or whatever affects process capability. Within the current capability, these common causes produce the level of variation you must accept**.**

Jawad, Abdulkader and Ali (2009-179 said that, for organizations to improve, they must improve the capability of the system. In software projects, the technology level and choices one makes, and the architectures within which it is operated, impose direct limits on cost, time, and quality of the project tasks.

Buffers to control variation

Shou and Yao (2000-163) indicated that most project methodology places safety margins (buffers) in the project schedule while pushing individual tasks to completion in the shortest time possible. The buffers added to the project allows the project manager to manage common causes of variation in the tasks on the critical path or critical chain. Izmailova, Kornevab and Kozhemiakinc (2016-45), indicated that the best way of allocating time to these buffers is to base the size of the buffer on the variance of your processes. According to Trietsch (2005-271), project manager applies and monitors four specific buffers that allow for contingencies where resource risks have the greatest impact on a project:

- **Project buffers** - Project buffer protects the project from missing its scheduled end date due to variations along the critical chain, by placing a portion of the safety margin time that removed from each task estimate into a buffer task, thus moving the times of uncertainty from individual tasks to a pooled buffer task.

- **Feeding buffer** - This buffer minimizes the risk that late completion of a non-critical chain/path task will affect the critical chain, achieved by inserting an amount of time at those points in the schedule where inputs from non-critical chain tasks merge with critical chain tasks

- **Resource buffer** – This buffer is an alert that is sent to critical resources to ensure that they have time to complete their current tasks and begin to prepare for the critical chain task so that work can begin on the latter task as soon as the former task is completed.

- **Capacity buffer** – This buffer places on-call resources that are available to avoid schedule delays due to unforeseen issues into the budget, achieved by adding additional cost to the budget. This time of buffer is seldom applied because such an expense goes against most organization's cost control principles.

González, Alarcón, Maturana and Bustamante (2011-710) believed that, during project monitoring and control phases, monitoring the buffers becomes a principle task for the project manager. Blaszczyk, Blaszczyk and Kania (2013-381) alleged that closely monitoring the consumption of buffers and frequent updating the time-to-complete for individual tasks and replenishment allows the project manager to track actual project progress against the original schedule. Yoshida, Takahashi and Goto (2010-1634) point out that on the most critical aspects of the project, the project manager can effectively analyze current progress, implement corrective actions, and maintain focus.

Blockchain background

According to Hazır (2015-811), a blockchain is a digital transaction ledger, maintained by a network of multiple computing machines that are not relying on a trusted third party and individual transaction data files (blocks) are managed through specific software platforms that allow the data to be transmitted, processed, stored, and represented in human-readable form.

- **Distributed ledger technology (DLT) - According** to Belle (2017-282), the original premise of blockchain is to establish trust in a peer-to-peer (P2P) network circumventing the need for any sort of third managing parties. Such a trust is in the form of verifiable mathematical evidence.

- **Hashing:** According to Basden and Cottrell (2017-6), a hash is defined as a unidirectional cryptographic function. A hash function usually takes an arbitrary input of an arbitrary length and outputs a seemingly random fixed-length string of characters. Each such output is unique to the input given to this function and can be considered the footprint for an input. Kshetri (2018-84) designated that if the input is even so slightly changed then the output of the hash function almost always completely changes in a random fashion (there are, however, rare occasions where a collision occurs when two distinct inputs to a hash function map to the same output)

- **Transaction chain** – According to Turk and Klinc (2017-641), each block in a blockchain contains multiple transaction chains. Each transaction chain in turn shows the value transferred from one peer of the network to another.

- **Distributed consensus:** According to Wang,Wu,Wang and Shou (2017-72), blockchain systems make use of different consensus engines. Lee and Yoon (2019-41) thought that these engines enable peers of the blockchain network to have a say about the overall state of the records stored in the blocks of a blockchain network and the widely adopted consensus protocol is Proof-of-Work (PoW). The other two are the Proof-of-Stake (PoS) and Proof-of-Authority (PoA) based consensus engines

Blockchain and project control

According to Lee and Yoon (2019-43), project managers can easily measure, monitor and control project progress using blockchain applications because the blockchain implementation rules out any bureaucratic environment in project management. Turk and Klinc (2017-641) held that in the blockchain network, no one can bluff others because everyone is connected to each ensuring that everyone upholds the accountability of the project team members. Belle (2017-284) held that in project management, a user with the private key can register transactions in the blockchain and a manager can assign roles and manage permissions for their team members by assigning a private key to them. Hazır (2015-811) believed that public keys are used to derive addresses where information will be sent or received.

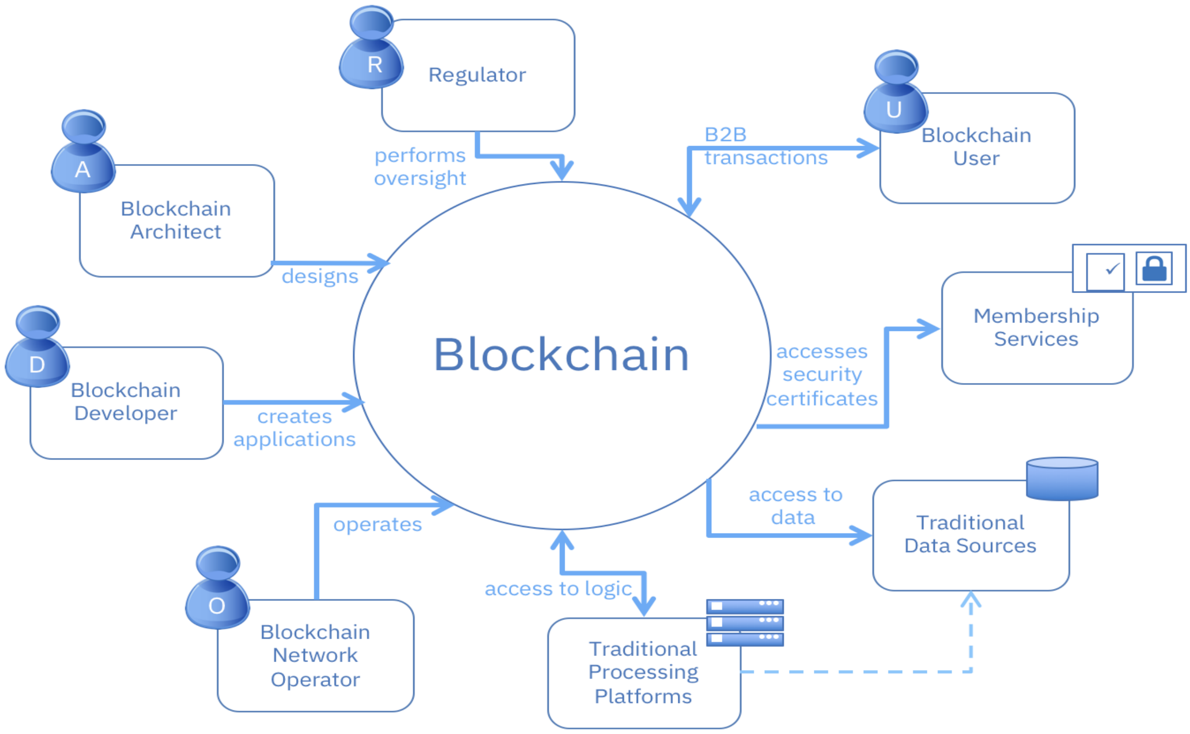


Figure 1 Overview of a blockchain technology (Turk and Klinc, 2017-642)

Blockchain works in real-time and its transactions are recorded 24/7. Therefore, when you perform a blockchain transaction, you can expect a quick turnaround and this is exactly what's required in project management. Hazır (2015-811) assumed that blockchain can assist project managers to accurately managing task dependencies, defining roles & responsibilities of team members, ensures secure transfer of data, and prevent time overruns which will lead to drastic cost reduction. This will enable most project organizations to be able to complete the project without exceeding the budget limitations. Although most project managers use project management software and methodologies to drive the majority of the project, there is an urgent need to increase the efficiency of the entire process according to Basden and Cottrell (2017-8). Kshetri (2018-84) indicated that blockchain holds the potential for revolutionizing the project management domain, however, there is a need for a lot of research & development in this field.

Research methodology

A case study, which is structured and written from the viewpoint of a key player and is framed around information available to the protagonist at the time of the event. The case typically builds to a point where the decision-maker is confronted with open-ended choices, then leaves the reader to analyze the information and make critical decisions based on contextual analysis. The rationale for case-based learning is that knowledge is most useful when it is shared among organization members and when it is contextual, that is, when it relates to one's own experience. The case study was performed following a 10 steps approach to case writing as recommended by the National Aeronautics and Space Administration (NASA):

Step One: Pick a Target

The case study is about thermal power plant water balance system construction project .

Step Two: Define the Parameters of the Case

The triple constraint theory in project management says every project operates within the boundaries of scope, time, and cost. A change in one factor will invariably affect the other two. Monitoring scope changes enables us to discuss trade-offs early and make necessary adjustments before the project gets off course. This case study will focus on the following parameters:

- Scope variations
- Time (schedule) variations
- Cost (budget) variations

The main purpose will be to look at the blockchain technology characteristics and the impact that it can make to the towards project triple constraints if applied by the project manager compared to other centralized project management techniques.

Step Three: Do the Homework: Background Research

Generally, project management for power plant construction is set to have functions such as the establishment of project basic plans to enable construction work to be performed properly following quality requirements, within budget and schedule, preparation for project organization and management including control and adjustment of a division of responsibility. The following are critical construction phases of the power plant project:

- **Awarding of Contracts** - The civil works, boiler, turbine, auxiliary plant, electrical and control and instrumentation contracts form part of the main contracts in terms of which the overall construction plan is implemented. Derived from these, many smaller companies are involved as sub-contractors.

- **Site Establishment** - This phase deals with the provision of the infrastructure required for the main contractors to begin work. Land needs to be leveled, water, sewerage, and electrical services to be provided, roads constructed and construction offices established. The terrain needs to be fenced off and security control and first aid facilities put in place.

- **Construction** - Construction starts with the setting out and excavation of foundations. If the power station is to use a conventional wet-cooling system, the trenches and pipework for the cooling water ducting must be in place before construction of the turbine hall commences. Although several areas are under construction at the same time, the main areas are the foundations of the boiler house, turbine hall, cooling towers and chimneys. The period from site establishment and commencement of civil work, to the point where the first boiler and turbine can be commissioned, is approximately four years. Subsequent units would be commissioned at intervals of nine to twelve months.

- **Commissioning** - Auxiliary plant systems need to be commissioned first to provide logistical support for boiler and turbine operation. These include water treatment, coal supply and ash handling systems, electrical supplies, and the transmission network. Boiler and turbine commissioning initially involves the cleaning of all water, steam, and auxiliary pipework. Important equipment such as motors, pumps, lights, and control circuits are among the first items to be commissioned. Safety checks and testing are carried out before any plant is commissioned. Plant and equipment that have been commissioned are taken over by the operator, although the contractor remains responsible for defects. A production unit (boiler, turbine, and generator) is taken over by the operator and put into commercial operation once all the tests have been successfully carried out.

Step Four: Interview Key Players to Get Their Story

According to VGB power tech (2016- 45), the completion of Medupi and Kusile which are the largest construction projects in the southern hemisphere has been significantly delayed, with the original commercialization operation date for the first units of 2012 Medupi, and 2013 for Kusile. Causes for significant delays:

- Instructure and skills development
- Overall project measurement, monitoring and control
- Late decision marking that led to contractual specifications issues
- Incorrect designs
- Use of incorrectly approved welding procedures
- Strikes and labor unrest
- Payment disputes

The results to all the causes are major time overrun cost overruns and huge scope variance.

Step Five: Evaluate Story Lines for Learning Points

Blockchain technology has very high potential to transform the organization and practices of project management offices (PMOs). There are five key areas were blockchain-based platforms and applications can support the efforts of the PMO which include creating and managing digital records, exchanging digital assets, verifying and reinforcing acceptable performance, building reputation systems, executing smart contracts, and measuring, monitoring and control projects. Concerning the above causes of significant delay specified, the following block chain characteristic can address

- No Malicious Changes: Distributed ledger responds well to any suspicious activity or tamper. As no one can change the ledger and everything updates real fast, tracking what's happening in the ledger is quite easy with all these nodes. This will reduce projects under-reporting or over-reporting as everything happens in real-time.

  Ownership of Verification: Nodes act as verifiers of the ledger. If a user wants to add a new block others would have to verify the transaction and then give the green signal. This provides the user with fair participation and will assist project managers to ensure that task changes can be seen timely, by everyone involves as soon as it happens and their approval is required for changes to be accepted.

- No Extra Favours: No one on the network can get any special favors from the project manager. Everyone has to go through the usual channels and no one can have more power so they can get more privileges.

- Managership: To make the blockchain features work, every active member has to maintain the ledger and participate for validation. This means that task managers are in full control of their tasks and project manager just ensure they account for their actions.

- Quick Response: removing project data captures will quicken the response time. Any change in the ledger is updated in minutes or even seconds because those responsible for task update directly were tasks are happening

- User Control: With decentralization, users now have control over their properties. They don't have to rely on any third party to maintain their assets. All of them can do it simultaneously by themselves.

- Transparency: The decentralized nature of the technology creates a transparent profile of every participant. Every change on the blockchain is viewable and makes it more concrete.

The most obvious benefit of blockchain in projects is its ability to maintain an immutable record of events using distributed ledger technology (DLT). You can also use the information in the ledger to analyze business operations to find new efficiencies and savings of time and money. Blockchain can help to investigate discrepancies and disputes because it is a single trusted and automatically updated record (tamperproof).

Step Six: Draft the Case into a Narrative

A transaction chain is shown in a blockchain allows each block in a blockchain to contain multiple transaction chains and each transaction chain in turn shows the value transferred from one peer of the network to another. The figure below shows a blockchain transaction chain, each block is developed in sequence. The block header determines the node in a blockchain, and the block contains all block transaction data.

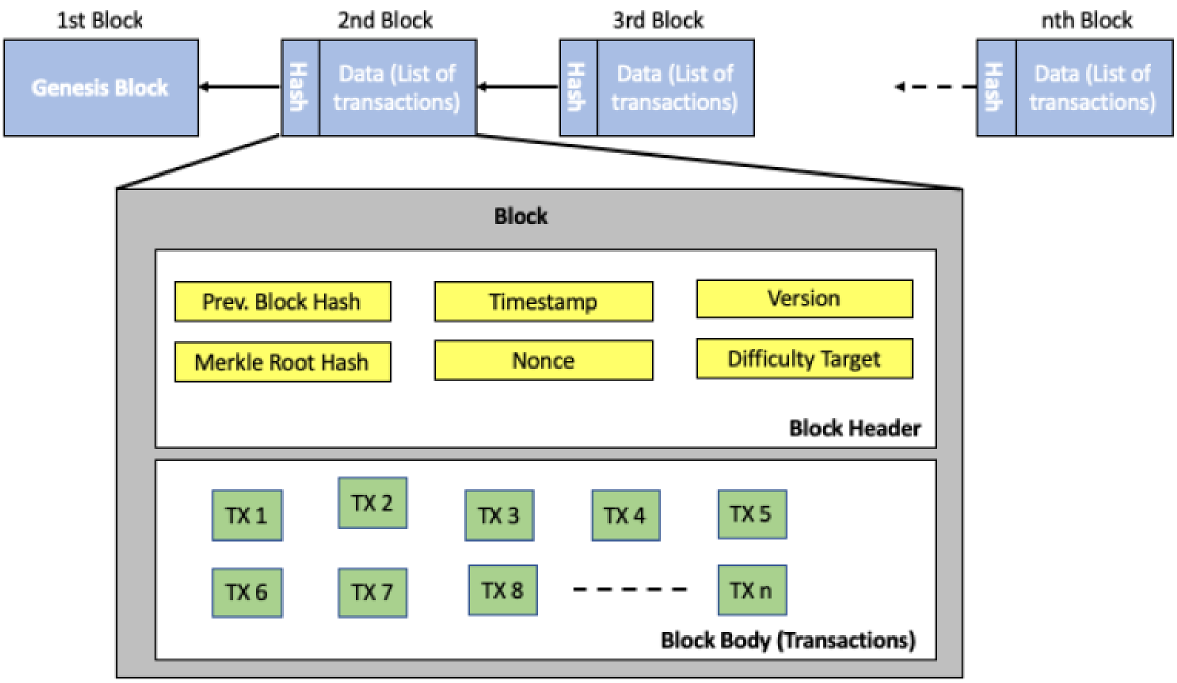


Figure 2 Blockchain header and genesis block (Kamilaris,Font and Prenafeta-Boldú, 2019-2)

The figure below shows that using the hashing technology allows transactions or tasks to be handed over to the next team, while the transaction timestamp is kept on the network available for the project team to view. Task owner digitally sign out the task to ensure that the next owner except to start his task.

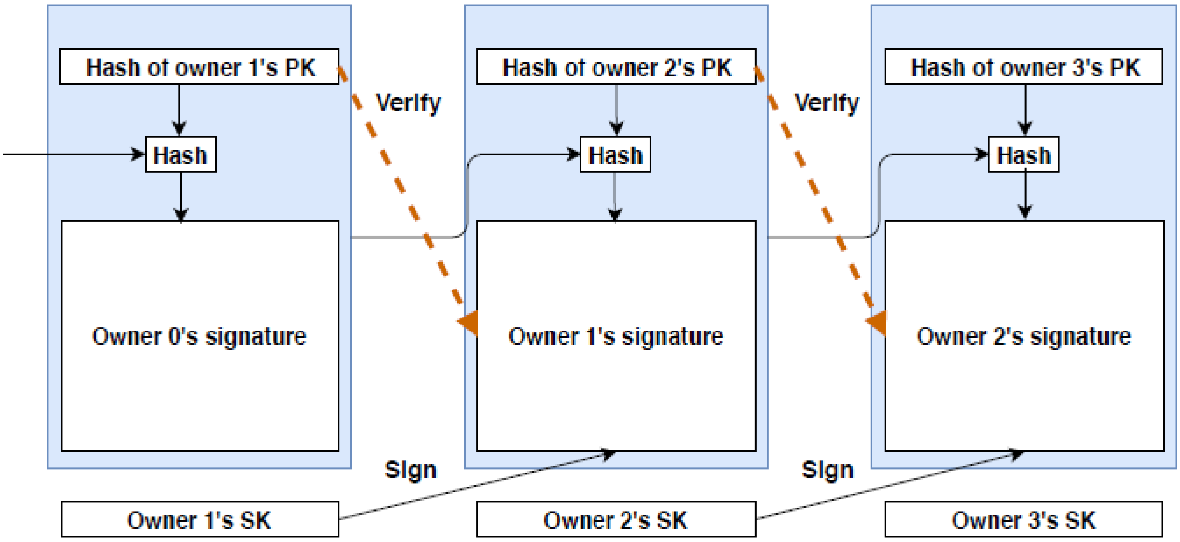


Figure 3 Blockchain owner and approvals
(Ali, Latif, Qadir, Kanhere, Singh and Crowcroft, 2019-4)

One of the advantages of using blockchain is the application using smart contracts which are conditions set out for every task visible to anyone. This contract is a set of logic rules in the form of a coded script, which can be embedded into the blockchain to govern a transaction or task. Using the earned value method, the 10 M variations from June are calculated as per figure below.

Belle (2017:11) indicated that the blockchain governance structure is distributed with input from all blocks on the blockchain network which makes the transaction very transparent in the network. Blockchain networks are characterized by self-governance containing built-in control points and incentives to help maintain the right balance and transactions go through a series of decentralized processing steps, with a decision that offers transaction finality as the output. This governance structure is based on incentive economics and consensus. The details on blockchain blocks are shown in the figure below.

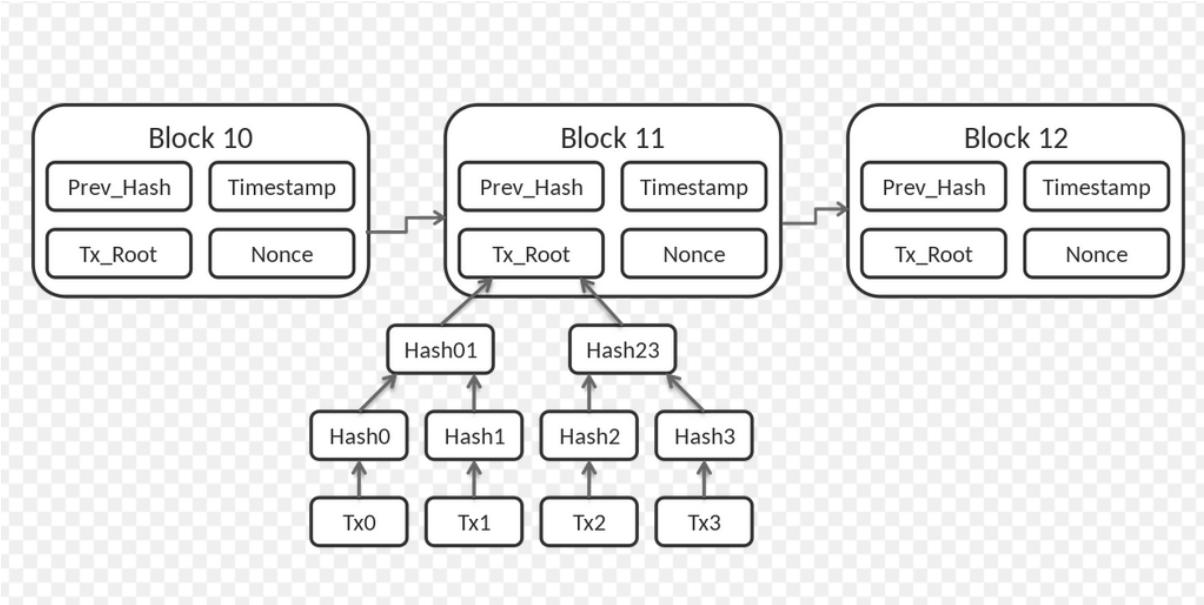


Figure 4 Details of a blockchain block
(Ali, Latif, Qadir, Kanhere, Singh and Crowcroft, 2019-4)

Blockchain in project environment application (10-month duration)

Consider the design installation of an ash water recovery system in thermal power plants that can be installed 10 months. The operation of the ash water recovery (AWR) system broadly involves supplying 1400 M3/hour clear water employing operating various pumps & auxiliaries. Horizontal centrifugal clear water pumps of 530m3/hour. sludge disposal pumps of capacity 220m3/hour, 2nos. Alum dosing/metering pumps of 1200 ltr /hour capacity. Lime dosing pumps of 1m3/hour capacity. Alum preparation tanks fitted with high-speed agitator. Motor-driven flash mixers with turbine type agitators, dewatering pumps by operating various manual/ electrically operated valves e.g. Butterfly, Sludge, Gate, Globe, Sluice, Air release valves, etc. for discharging the clear water in these lines to all the ash handling plants of Unit 1 to 6. The project activities can be summarised as shown below:

Table 1 AWR project data

Block	**Dependence**	**Period (Days)**	**Max duration**	**Task**	**Responsible person**
A		70	10	Contract award	Joseph
B	A	35	50	Design and procurement	Takalani
C	A	50	50	Design and procurement	Andries
D	A	43	50	Design and procurement	Alfred
E	BCD	27	40	Construction	Sam

F	BCD	38	40	Construction	Philip
G	BCD	40	40	Construction	Sammy
H	BCD	35	40	Construction	Philip
I	EFGH	20	20	Commissioning	Joseph

From the above, it is noticeable that using the critical path method (CPM), or critical chain method, the critical activities AGFI is 208 days. The blockchain network is without considering the float and buffers available for critical path 2 and 3. The above system block chain as shown below:

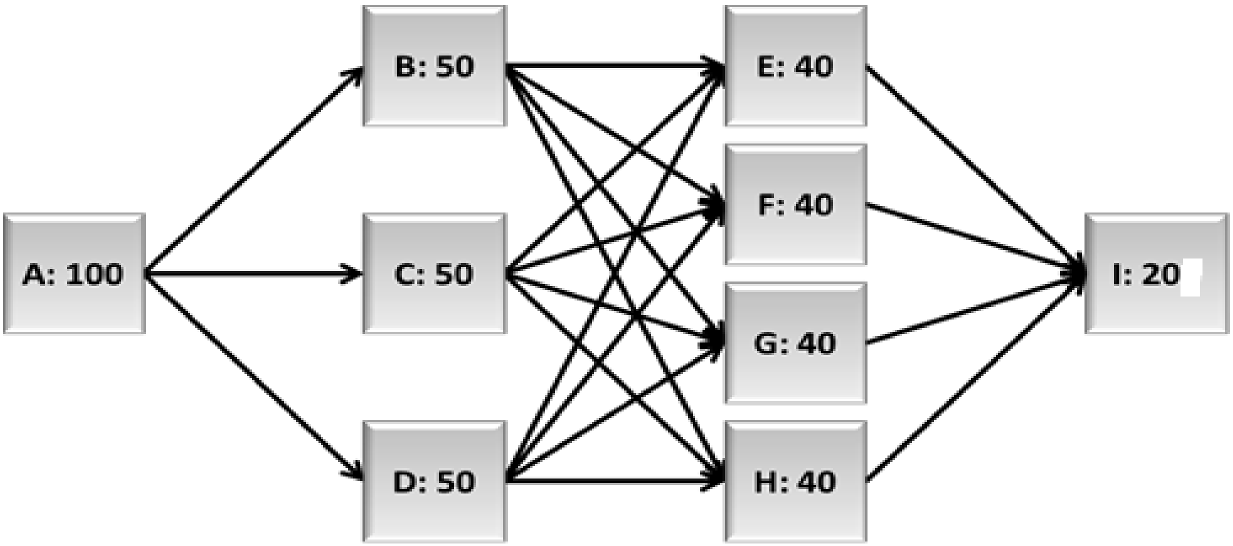


Figure 5 AWR project, blockchain block diagram

As part of the blockchain transaction data, all information regarding the project task is communicated throughout the project process phases, which is to identify the requirement for each block and assumptions on which the project is built Bellow, are all project information required recorded under each block, blockchain transaction data:

- Goal (Why - outcome required for the block, which includes (KPI) and key performance area (KPA)
- Critical success factors (What - project tasks/process input)
- Assumptions and constraints (Why - project tasks/process limitations on inputs)
- Objectives (What project tasks/process outputs are required)
- Individuals and groups involved (including contract details) (Who is responsible for project tasks/process input)
- Who is responsible (Who is responsible for project tasks/process input)
- Actions by whom (How - project tasks/process followed)
- Risks (What - project tasks/process risk input)

- Resources (changes to current situation) (What—Input)
- Dependencies (What— project tasks/process input dependencies)
- Costs (What - project tasks/process cost input)
- Start time (When - project tasks/process Input)
- Complete by time (When - project tasks/process input).

Depending on the organization, the gate (end of phase milestone) may be passed through a successful business case and/or a contractual agreement reached in addition to the project charter.

Analyses using the earned value method (EVM)

The most commonly used method for project measurement, monitoring, and control is the earned value analysis (EVA) which is defined as a method that allows the project manager to measure and monitor the amount of work performed on a project beyond the basic review of cost and scheduled reports. This method permits the project to be measured by the progress achieved. The project manager measure progress and forecast a project's total cost and date of completion, based on the application of the project's burn rate. The table below shows our water recovery project Earned value data for 10 Month:

Table 2 AWR project EVA data

Project Earned Value Analysis
Ash Water Recovery Project

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Budget at Completion (BAC)	$1 500	$1 500	$1 500	$1 500	$1 500	$1 500	$1 500	$1 500	$1 500	$1 500
Earned Value (EV)	$100	$200	$300	$450	$750	$800	$1 125	$1 250	$1 320	$1 380
Actual Cost (AC)	$100	$205	$315	$600	$800	$1 000	$1 200	$1 350	$1 475	$1 625
Planned Value (PV)	$100	$220	$325	$550	$725	$925	$1 175	$1 275	$1 450	$1 500
Cost Variance (CV)	$0	($5)	($15)	($150)	($50)	($200)	($75)	($100)	($155)	($245)
Schedule Variance (SV)	$0	($20)	($25)	($100)	$25	($125)	($50)	($25)	($130)	($120)
Cost Performance Index (CPI)	1,00	0,98	0,95	0,75	0,94	0,80	0,94	0,93	0,89	0,85
Schedule Performance Index (SPI)	1,00	0,91	0,92	0,82	1,03	0,86	0,96	0,98	0,91	0,92
Estimate to Completion (ETC)	$1 400	$1 333	$1 260	$1 400	$800	$875	$400	$270	$201	$141
Estimate at Completion (EAC)	$1 500	$1 538	$1 575	$2 000	$1 600	$1 875	$1 600	$1 620	$1 676	$1 766
Variance at Completion (VAC)	$0	($38)	($75)	($500)	($100)	($375)	($100)	($120)	($176)	($266)
Status based on Average Performance Index	GREEN	YELLOW	YELLOW	RED	YELLOW	RED	YELLOW	YELLOW	YELLOW	YELLOW

Earned values quantify the worth of the work done to date informing the project team, in physical terms, what the project has accomplished. The graph below shows our project Earned Value (EV) for the 10 months.

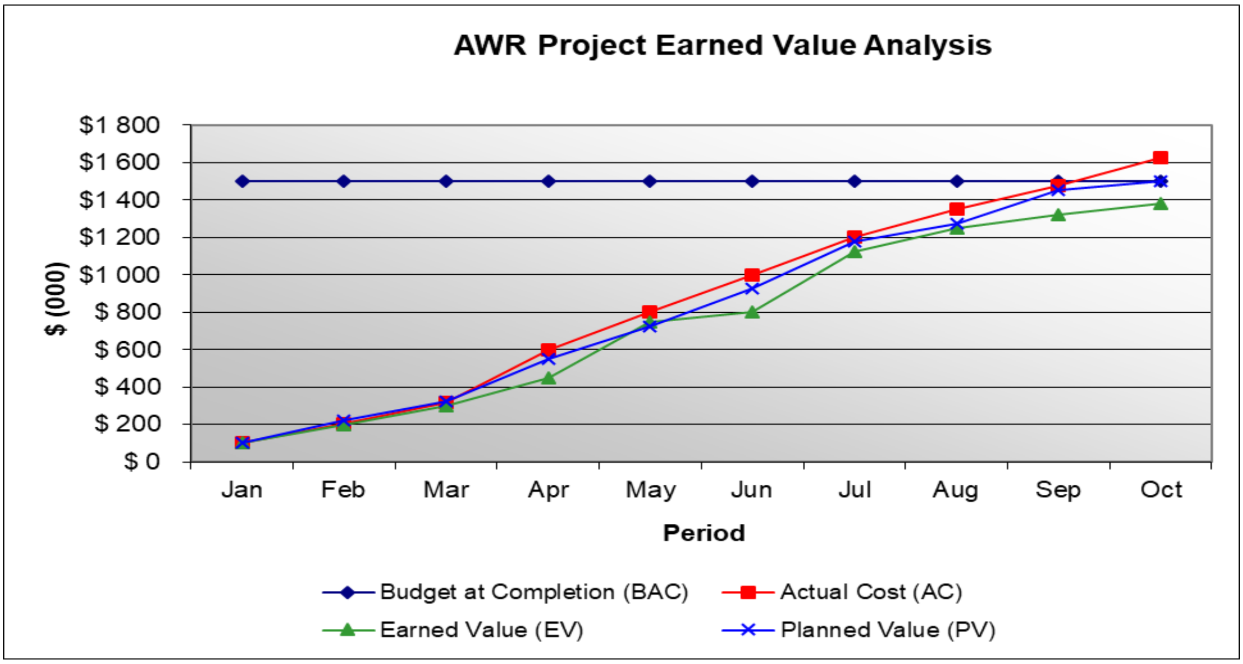


Figure 6 AWR project EVA

The project performance index is used to measure the project burn rate when utilizing Earned value analysis (EVA). To achieve this, the project manager uses the schedule performance index (SPI) and the cost performance index (CPI) to measure project performance. The graph below show the AWR project performance index

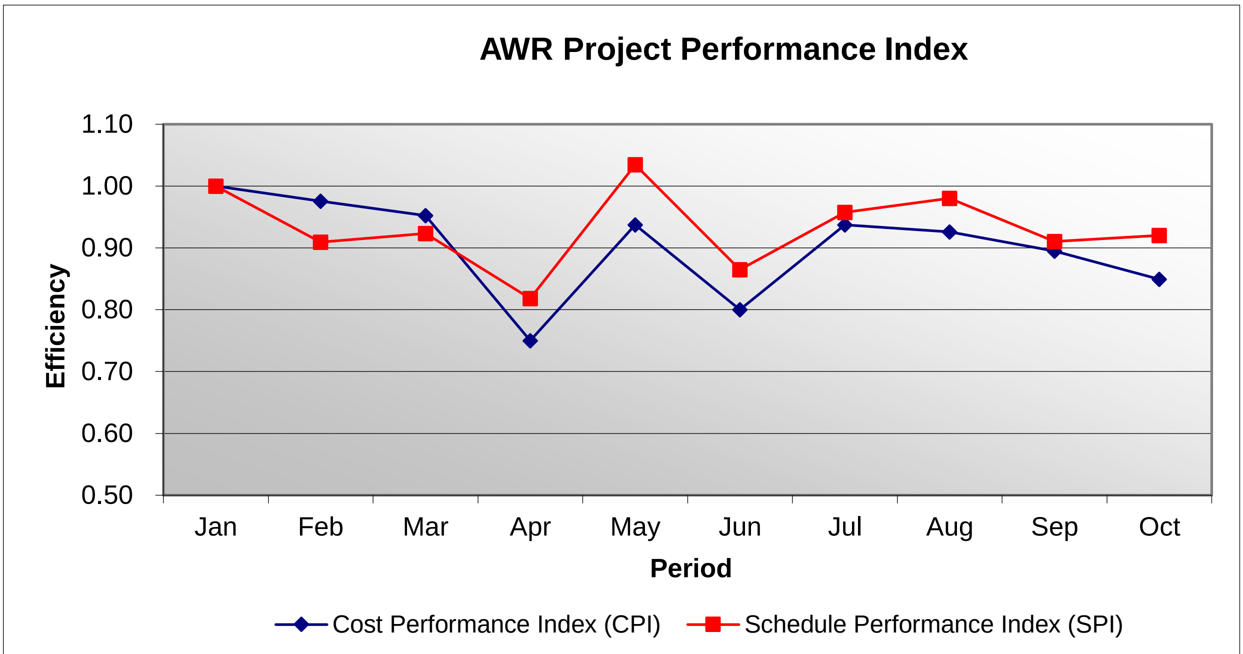


Figure 7 AWR project performance index

Project variances are divergence, deviation or departure that can be quantified from a known expected value or baseline. The project cost, scope, schedule and quality are estimated, as project-planning component become known. The graph below show the AWR project variance analysis over a 10-Month period.

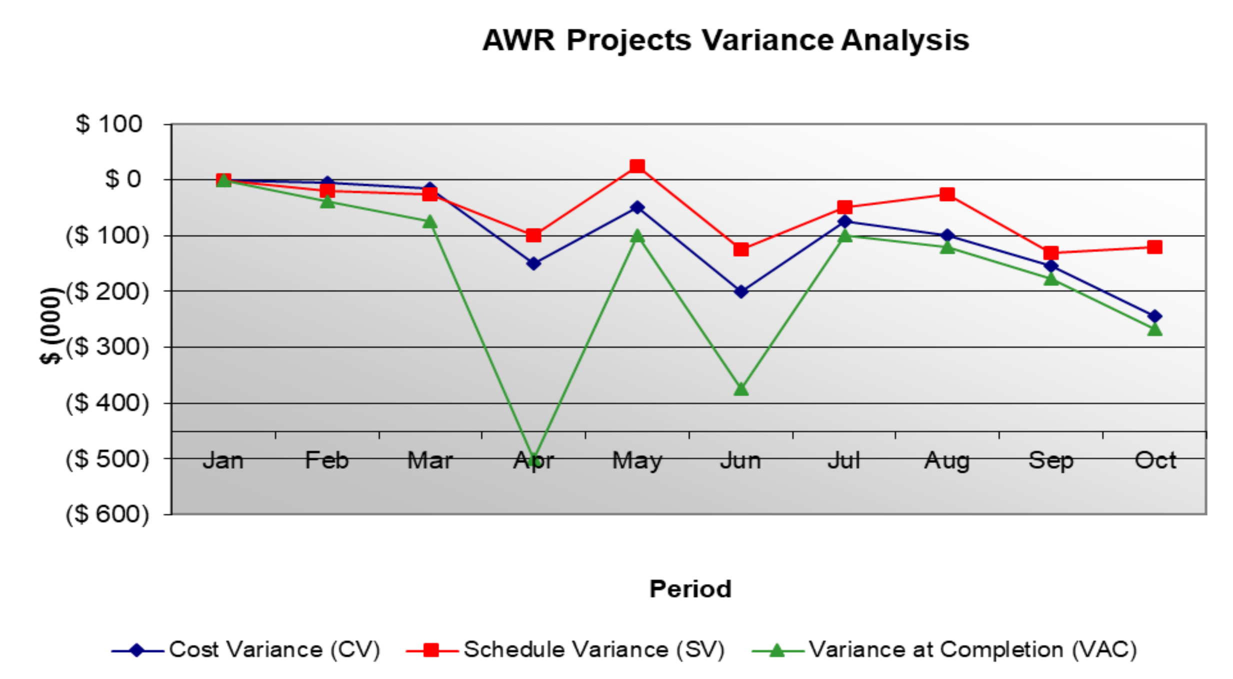


Figure 8 AWR project variance analysis

Using the earned value analysis method (EVA) to measure and monitor performance, the project progress measurements reported to date assist the project team to analyse the future or what is expected to happen on a project. With the available information at hand, the project team determines how much the project will cost and when the project will be completed, using future projects requirements. The graph below show the AWR project estimate at completion for 10-month period.

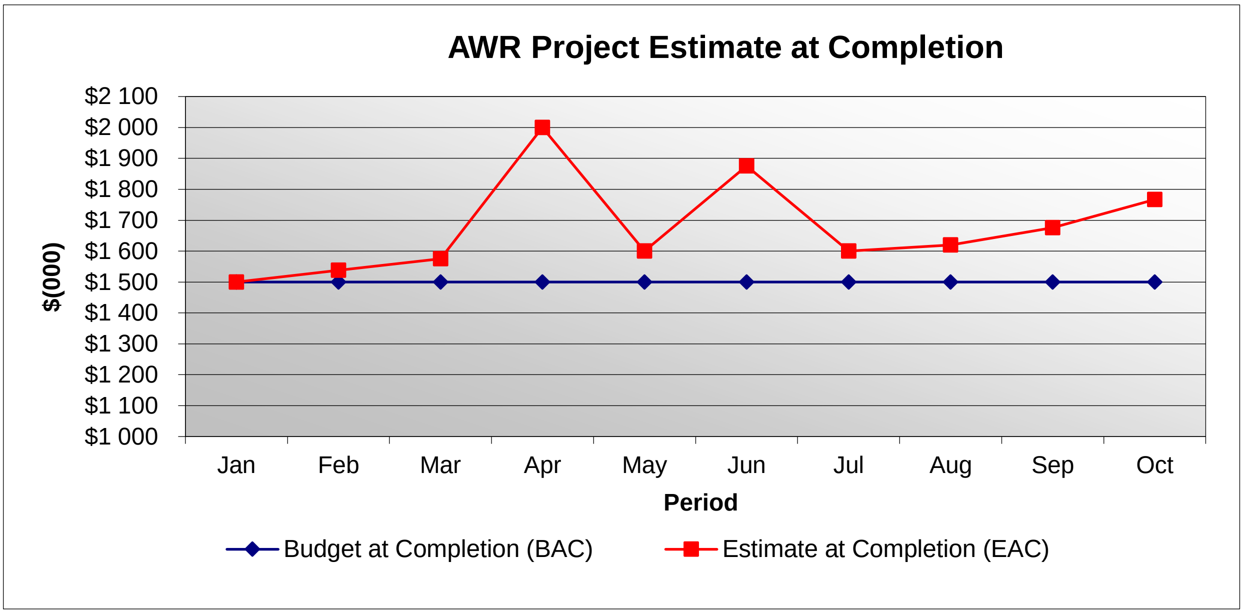


Figure 9 AWR project estimates at completion

As compared to the current centralised system, the block chain system allows this measurement to update in real time as task responsible person updates the block in a block chain network. This will significantly reduce the utilisation of buffers and eliminate time wasted between activities due to its transparency.

Step Seven: Process and task variations in project theory review

The improvements of project measurement, monitoring and control also referred to execution management is very dependent on project planning and estimation accuracy. To theory of measurement, provide a deeper understating of project task time and how task and project duration can be removed. The understanding of project measurements effect on project success, more specific of time and project duration contribute additional understanding. The theory of measurement specific to project duration using blockchain technology was assessed as indicated in the figure below:

Figure 10 analysis approach

The best way to monitor project behavior is to adopt critical chain project management (CCPM) which requires durations to be reduced by 50% and then use a buffer to monitor schedule performance. This can be monitored by dividing the activity into two halves:

$(\mathrm{D_a} = \mathrm{D_1} + \mathrm{D_2})$

Project capability requires the development of a standard process model for the steps of the life cycle, specifying the processes with their inputs and outputs and the workflow dependencies between those processes followed by a project plan build around the deliverables. To calculate the overall cost of a project task (splitting a task into two halves):

Note: Example below on Duration, also apply to cost, scope and risks

$$\mathrm{D_a} = \mathrm{D_1} + \mathrm{D_2}$$

Where:

D_a = Actual duration of a task

$\mathrm{D_1}$ = 50% duration cost of task

$\mathrm{D_2}$ = 50% duration cost of task

Therefore:

50% actual duration of a task (D_1) = ($1.15D_{u1} - 0.85D_{L1}$) = 0.30 D_1 and

50% actual duration of a task (D_2) = ($1.15D_{u2} - 0.85D_{L2}$) = 0.30 D_2

Where:

D_u = Highest duration of a task

D_L = Lowest duration of a task

Corresponding standard deviation is:

Standard deviation (σ_1)= ($0.30D_1$)/6 = $0.05D_1$

Standard deviation $(\sigma_{2})=$ $(0.30D_2)/6 = 0.05D_2$

The standard deviation of the sum can be calculated:

Elementary statistics state that the standard deviation of the sum of two independent random variables is equal to the square root of the sum of the squares of the individual standard deviations

Therefore:

Standard deviation $(\sigma_{1+2})=$ $0.05\sqrt{D_1^2 + D_2^2}$

The formula above indicates that the standard deviation of the sum of the two estimates is smaller than the standard deviation of a single estimation.

Process and task variations in project

Project system issues formulation identifies the needs to be fulfilled, the requirements associated with it in terms of the project objectives to be satisfied, constraints, and alterable that affects issue resolution, and generation of potential alternate courses of action

The core concepts required for the development of PSLCM relate to the improved detailed understanding of project variations control and its components.

The project variations are calculated:

$$\boldsymbol{Vp} = \sum_{\boldsymbol{cp}} \boldsymbol{Vt} \ldots \ldots \ldots \ldots \ldots (\mathbf{1})$$

Where:

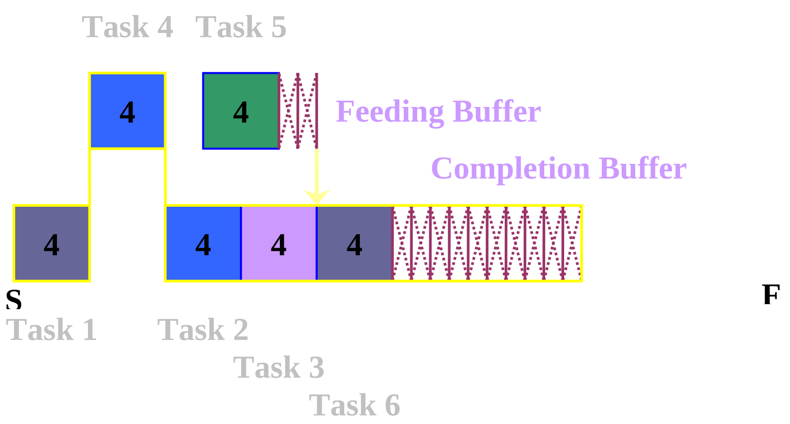
Vp = Project variation

Vt = Sum of task variations

Cp = Critical path/Critical chain

Project variations, buffers and capabilities

The buffer is also used to manage project cost but firstly acknowledging that the use of buffers is not budgeted for in any project, secondly by considering the unique aspects of each project that affect the ability to estimate accurately. The figure below indicates how buffer management is used to improve project performance.



The project cost and schedule buffer can be calculated as follows:

$$V_B = P_B - B_B$$

V_B = Variations buffer

P_B = Project buffer

B_B = Bias buffer

The following procedure was developed to use buffers to manage project variations.

$$Bp = \sum Te - Td - Ta - Tr$$

Bp = Buffer saturation

Te = Sum task estimates

Td = Days elapsed

Ta = active task

Tr = Remaining task

Step Eight: Test the Case

The analyses of project variations and task variations have established that the project due date risks can be reduced significantly without any negative impact on environmental regulatory compliance, cost, safety, and quality. It was also noted that project delays are mostly affected by contractual incentives not being aligned with project goals for example, resources contracted with cost-based contracts, resulting in reductions of earnings for early completion. The analyses of duration variability make it evident that requirements exist which impact on the successful implementation of the project specifically related to the macro-organizational environment which can include the alignment of corporate incentives with project measurements and demands, addressing the suspicion due to past negative experiences and challenges in the trust relationship between project workforce and project management.

Step Nine: Create a Teaching Note and an Epilogue

Brief description of the case setting and key issues

Every year, organizations waste billions of money due to high project failure rates. Although there is a lot of project tools and techniques regarding project measuring, monitoring, and control, the challenges of project progress measurement accuracy persist. It is important to remember that, although project measurement depends on the project plan, it is of utmost importance to have an efficient system because the project manager relies on measurement, to effect control so that he can manage project activities.

Clear learning objectives

It has become evident that a distributed monitoring and control system can bring almost real-time data from project activities. This will assist the project team to manage and control the project because accurate timely information in real-time needed for critical decisions is available. This will also improve lead-time to resolve project disputes. Using blockchain technology can improve project monitoring and control because the same qualities that make it ideal for handling currency transactions also make it useful for handling sharing information, sending reports, handling payments, and ensuring completion of tasks. Blockchain technology can greatly support efforts of the project management office (PMO) by verifying and reinforcing acceptable performance in the project bringing the potential to transform the organization and practices. This technology also assists the project manager with automating record-keeping freeing managers for more challenging and value-adding activities.

Epilogue

Blockchain technology offers project management organizations a huge opportunity to correct some of the social ills that are causing an organization to lose billions annually. Although the technology is in its early stage, the transparency that it offers to public information, and privacy it has on private information, and the availability of data almost in real-time has provided an opportunity that can never be realized by using tradition centralised system.

Step Ten: Validate case

The project variations theory explained in this article expressed that the variability of project durations, cost, and scopes can significantly be reduced because of the system transparency, timely decision marking, and accountability distributed to task manager rather than the traditional system where management and control lies solemnly with the project manager. The figure below indicates variability simulated while using both centralized and de-centralized measuring, monitoring, and control system on the AWR project.

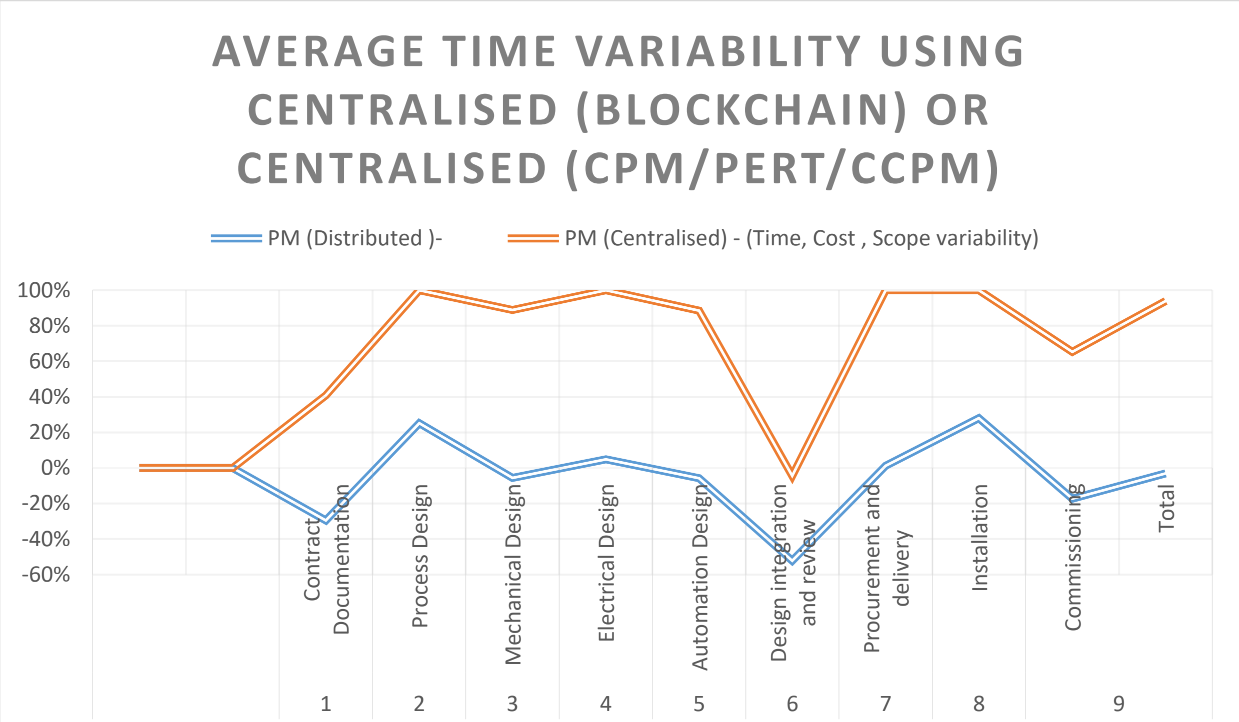


Figure 11 Variability comparison for distributed and centralized measurement and monitoring systems

Findings

This research used a case-based methodology to investigate how project monitoring and control can be improved using blockchain technology. The research findings for each research hypotheses as outlined in the research hypothesis, are analyzed in the following paragraph

Hypothesis 1

H_0 : Blockchain technology will not improve project monitoring and control performance which will allow traditional project systems such as EVA to improve accuracy.

H_1 : Blockchain technology will improve project monitoring and control performance which will allow traditional project systems such as EVA to improve accuracy.

The case study results in figure 11, regarding measuring variability indicated that the current centralized project monitoring and control tools are more variable bringing uncertainty to the project schedule as compared to a decentralized system that happens in real-time and where corrective actions are easily implemented. By using buffers to control task variability, the activity duration measurement accuracy will improve and eliminate the activity start-up delay times meaning that, either the predecessor activity is completed early or late, the successor will be continuously be informed in real-time.

From the above results H_1 : Is accepted - Blockchain technology will improve project monitoring and control performance which will allow traditional project systems such as EVA to improve accuracy.

Hypothesis 2

H_0 : Blockchain technology will not provide project real-time data by placing accountability to the lowest level of the work breakdown structure (WBS) which will generally improve the performance of the project management office (PMO).

H_1 : Blockchain technology will provide project real-time data by placing accountability to the lowest level of the work breakdown structure (WBS) which will generally improve the performance of the project management office (PMO).

The decentralized project measurement, monitoring, and control system requires everyone responsible for the task to update progress themselves without any time delay. This means that using other project monitoring and control systems such as the earned value method (EVM), critical chain project management (CCPM), project evaluation and review techniques (PERT) on a decentralized blockchain technology will improve overall monitoring performance because all will be done by execution team in real-time informing all project team about the activity progress and its variability which will allow the next task owners to avoid next acuities start-up delay times. The project schedule performance improvement will improve the PMO performance because more projects and programs will be complete on time, within cost and meet all technical requirements.

From the above results H_1 : Is accepted - Blockchain technology will provide project real-time data by placing accountability to the lowest level of the work breakdown structure (WBS) which will generally improve the performance of the project management office (PMO).

Conclusions

In conclusion, projects and project management are fundamental to human and business activity. Both strategy and strategic benefits are delivered through the successful implementation of projects. With project success this important, it is unfortunate that project success is not as consistent as one would prefer. The alarming statistics on project success, as well as many high-profile project failures, cause significant concern for the project management profession. Although blockchain technology is not a solve-all solution, it can bring many benefits in project management. Blockchain project measurement, monitoring, and control offers a new way for businesses to get projects done with greater efficiency with less cost and on time, as compared to traditional management practices.

Blockchain technology will also improve the efficiency of traditional project tools such as the earned value method (EVM), critical path method (CPM), project evaluation and review technique (PRT), and critical chain project management (CCPM). By applying the theory of measurement in blockchain project measurement and monitoring tool, measurement accuracy will improve which will result in a better time and cost performance.

Recommendations

Further research is required to remodel the project contracts management directly aligned with a specific blockchain block, which will ensure that all contractual agreements are operationalized. This will mean that, not only the contract manager would be worried about the specific requirement to be met but more responsibility can be transferred to a task responsible person using blockchain smart contracts, which are digital contracts that execute the transaction when all tasks, activity or project conditions are met.

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