# Accelerating Product Development

## A study in Blockchain-enabled Secure DevOps

DSCI DIGITAL·SUPPLY·CHAIN·INSTITUTE

Bitfury

Aricent

# Executive Summary 01

## Project

To improve revenue and profitability in software development processes, Secure DevOps methodologies, and geographically dispersed teams via blockchain-enabled workflows.

## Participants

The Center for Global Enterprise's (**CGE**) Digital Supply Chain Institute (**DSCI**) is an industry group that creates best practices for digital supply chain management,

**Aricent** is a global design and engineering company innovating for customers in the digital era and is recognized for industry certified best practices and a steadfast commitment to excellence.

**The Bitfury Group** utilizes the technology of the Blockchain to allow companies to successfully digitize their assets and safely transact them over the internet – making the world safer, simpler and more efficient.

## Background

As a part its research agenda, DSCI resolved to improve the industry's understanding of Blockchain and its applicability in digital supply chains.

In June 2017, DSCI engaged with Aricent – a Global Engineering Research & Design (ER&D) firm and institute member, to explore how blockchain could enhance software product development supply chains, and improve modern development operations (DevOps) processes. In collaboration with Aricent, DSCI partnered with Bitfury – a blockchain technology company to design and execute a DevOps focused blockchain PoC.

## Overview

The requirement of Secure DevOps in global organizations poses unique challenges to its implementation. These challenges arise in terms of scaling the solution to manage workflow across large, diverse and geographically dispersed development teams. Seamless collaboration across disparate environments

where automated processes and human developers can work symbiotically is required. To address these issues, the team collaboratively envisioned and developed a technical solution (PoC) structured as a single blockchain-based system. The automated solution facilitates trusted product development, increases developer efficiency, and delivers increased transparency .

## Objectives

- Generate revenue through product development lifecycle acceleration
- Improve profitability through process efficiency gains
- Increase transparency in collaborative (intra/multiorganizational) environments
- Enhance the Secure DevOps process utilized across the industry
- Create a competitive differentiator

## Why Blockchain?

- Smart contracts ensure development processes and workflows are realized as intended within or across organizations.
- Entities can verify requirements, tests, or change requests are executed as agreed upon, in a tool or environment agnostic manner. No single entity can overwrite data or override the process.
- Stakeholders from Security, Compliance, Legal, etc. can verify compliance with policies (e.g. only builds with accepted open-source packages move ahead) for trusted, automated releases. A single interface allows for processing exceptions, with all deviations from process logged immutably.
- Seamless integration of software licensing and billing upon software product release.

## Results

Post Blockchain POC deployment, results were collected from projects over the course of a month and the following observations were noted:

- Improved cycle time by **34 %**
- Increased productivity by **29 %**
- Improved quality by **11 %**

## Conclusion

Adoption of blockchain-enabled development techniques yielded significant quantitative and qualitative improvements. Blockchain-enabled workflows lead to faster product development cycles, and improved productivity – unlocking new revenue potential and generating increased profitability. The technology, and our solution, should achieve similar results when applied to large-scale projects across multiple industries.

The come very near
a true theory,
and to grasp its
precise application,
are two very
**different things**.

**Alfred North Whitehead**
English Mathematician and Philosopher

# Outline

# Overview



Blockchain has the potential to revolutionize supply chains and business processes by enhancing trust, transparency and efficiency. However, **many organizations are yet to appreciate** the precise application of blockchain technology, benefits and costs, and integration with conventional enterprise systems.

Commencing in 2016, the Center for Global Enterprise's (**CGE**) Digital Supply Chain Institute (**DSCI**), an industry group that creates best practices for digital supply chain management, resolved to improve the industry's understanding of blockchain and its role in boosting platform agility, demand visibility and data utilization. This included use-case development through a series of proof-of-concept (PoC) and pilot projects and quantifying the return on investment (ROI) of scaling blockchain applications.

In June 2017, DSCI engaged with **Aricent** – a global engineering research and design firm and institute memberto explore how blockchain could enhance software product development supply chains and improve modern development operations (DevOps) processes. Like a supply chain, DevOps processes include multiple steps and stages. These are often performed by entities that largely work independently of, but parallel to each other. And like supply chains, **DevOps ecosystems have inefficiencies where rework may be required**, product development status and the release quality or compliance posture are uncertain, development costs exceed budget and project durations exceed established timelines.

In collaboration with Aricent, DSCI partnered with **Bitfury** – a full-service blockchain technology company–to design and execute a DevOps-focused blockchain PoC. The solution utilized a blockchain to track the DevOps process and leveraged **Exonum** – Bitfury's private blockchain framework. The jointly developed solution aims to ensure DevOps process and data consistency, and create a trusted, efficient product-development ecosystem. Based on pilot results obtained from the PoC, we observe that the new approach has **the potential to improve cycle time by 34% , productivity by 29% and quality of the product by 11%** when a blockchain-enabled DevOps process is adopted.

The remaining sections of this report document the PoC scope and structure, pilot process and results, as well as future holistic solutions for organizations to enhance their DevOps environments and product development practices.

# Requirements and Process

With the hypothesis that utilizing blockchain technology in software development and DevOps processes boosts overall efficiency and increases transparency in collaborative environments, it was imperative to establish project objectives, development requirements and success criteria that quantified productivity gains and cost savings. Such objective validation was a precursor to future developments and broader adoption of blockchain. We pursued three steps to test the hypothesis:

## — Scope, Objectives, and Timeline

## — PoC Development and Showcase

## — Success Criteria & Next Steps

## Scope, Objectives, and Timeline

Aricent, Bitfury and DSCI established a joint team to ensure a pilot (Phase 1) could be developed in a six-week sprint. The team consisted of three resources from Aricent (40% allocation), six resources from Bitfury (80% allocation) and two from DSCI (20% allocation). Using DCSI's proprietary Blockchain Return Index, DSCI ensured each side provided resources to accomplish the objectives of the broader pilot and achieve the expected ROI based on jointly-committed investments. Pilot success criteria in the form of DevOps metrics were identified by Aricent, and the project commenced following DSCI's approval of the plan.

> **" We worked to make sure that Blockchain would create business value and the measured results far exceeded our expectations. "**
> **George Bailey, Managing Director , DSCI**

# Phase 1
## PoC Development and Showcase

During the six-week implementation in Fall 2017, the core pilot team met for an initial in-person meeting followed by bi-weekly, hour-long video calls. On average, three individuals from each organization participated in calls. Bi-weekly meetings ensured the project progressed as planned and enabled the team to collaborate on PoC design, development, test and integration phases. Project notes, messages, key documents and weekly action-items were stored in Basecamp, a publicly-available project management repository. A technical demonstration, along with initial PoC results, was presented at a panel discussion during DSCI's Executive Leadership Forum in Baltimore in October 2017.

# Phase 2
## Success Criteria & Next Steps

This phase involved technical adjustments to the PoC and its continued application on two production-grade Aricent projects for six weeks to obtain a reasonable sample size of data points. These values allowed for success criteria validation (detailed in Section 4). In parallel, the group established the future direction as detailed in Section 5.

# Technical Approach

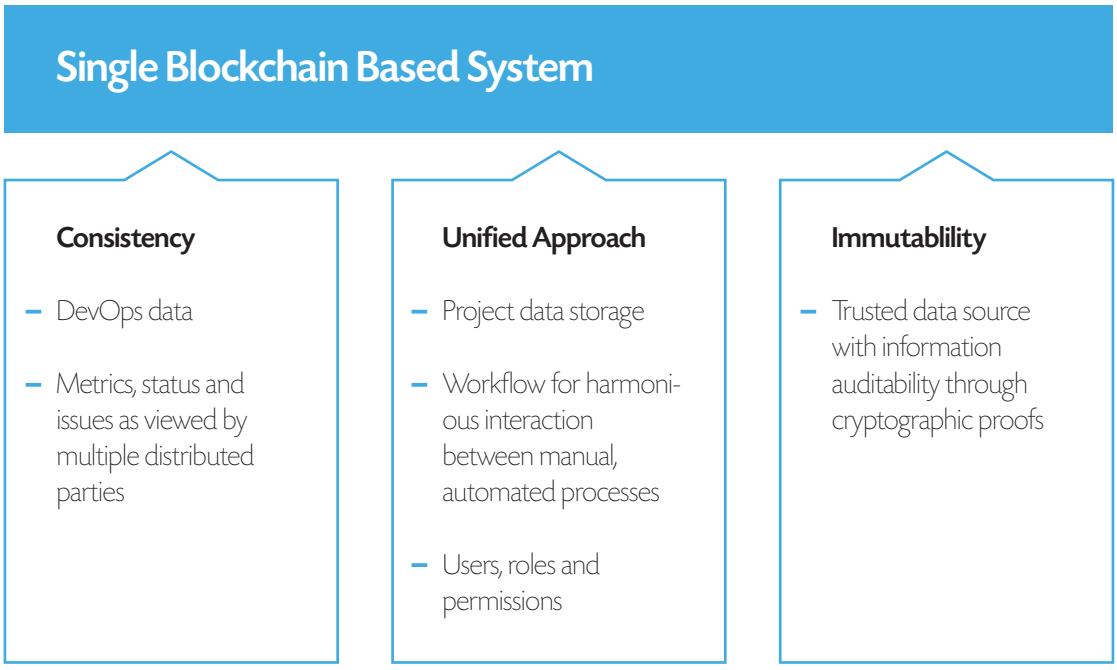



**Fig. 1. Advantages of a Blockchain-Enabled DevOps Solution**

Aricent and Bitfury collaboratively developed the technical solution (PoC), which is structured as a single blockchain-based system. (**Fig. 1**) The primary objective is to determine how such a solution can facilitate trusted product development, increase developer efficiency and deliver increased transparency among multiple entities that operate in a product-development environment.

Within the solution, a blockchain may be viewed as a distributed, fault-tolerant, tamper-resistant, append-only log of atomic changes (transactions) to a certain dataset (blockchain state). Timestamping each transaction enables a linear view and granular insights with respect to the software development supply chain.

The architecture utilizes blockchain as middleware between existing DevOps solutions and processes (e.g., GitHub, Travis, Jenkins, manual reviews, etc.). Development process state is synchronized via a private blockchain implementation, which serves as the authoritative source of truth for end users. Furthermore, blockchain-based smart contracts enforce approved development processes. (**Fig. 2**)

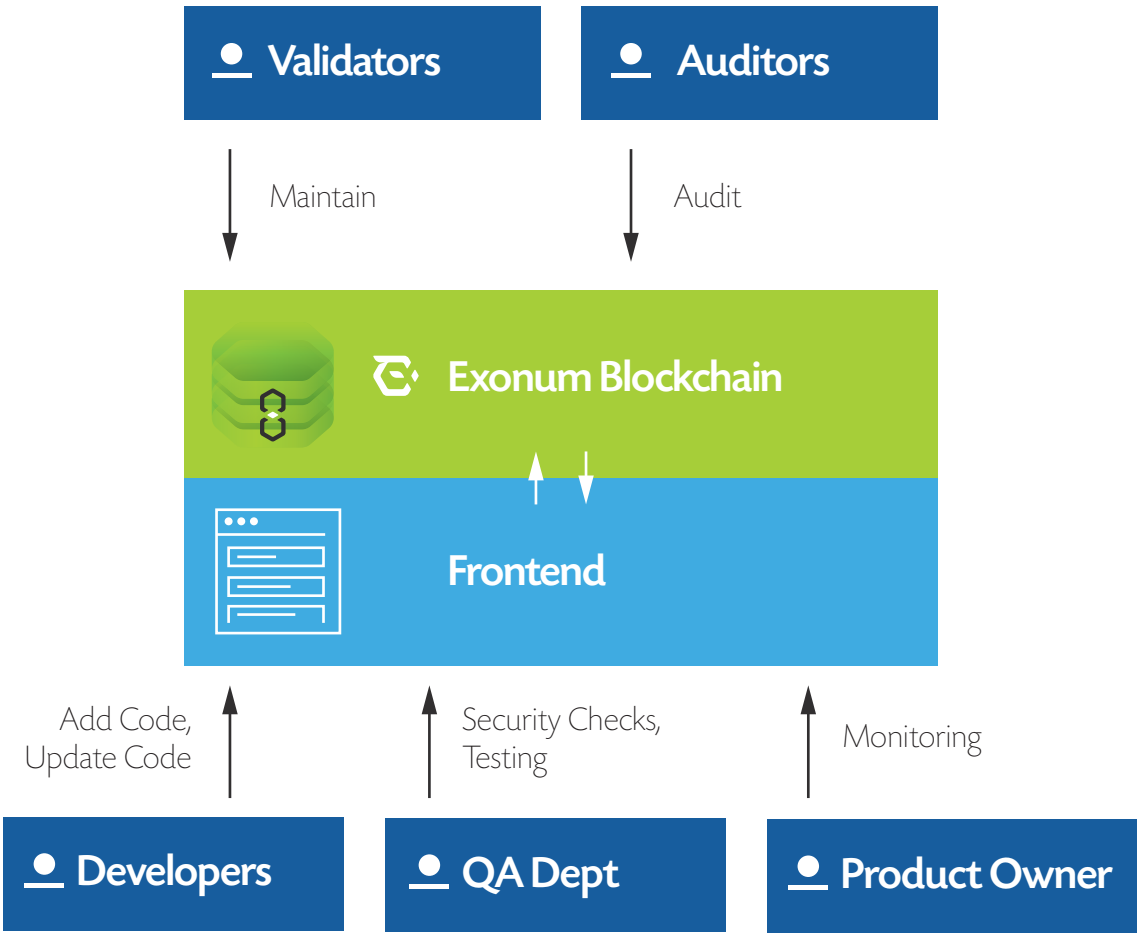



**Fig. 2. Solution Architecture, Roles and Responsibilities**

Leveraging blockchain technology at the middleware layer results in a few distinct benefits:

- **Synchronization (Data Consistency)**: The ledger provides a synchronized view of all project and tool data. End users have access to consistent – not contradictory – data
- **Security and Auditability**: The ledger provides a reliable, tamper-resistant and detailed audit trail of all stakeholder and user actions. Blockchain nodes may be spread across collaborating parties and geographical areas for a highly trusted, resilient data store
- **Scalability**: Manual and automated processes, which continuously poll status to trigger their own actions, can poll a distributed ledger as opposed to inelastic, federated systems
- **Improved User Experience**: The ledger serves as the base for an analytics and insights platform that provides unified system-wide views, improved compliance and concurrence amongst multiple, distributed user groups or stakeholders. Simultaneously, its role as middleware renders it transparent to development and operations personnel alike who continue to utilize their respective, familiar tools as before

PoC development yielded deliverables including a blockchain backend infrastructure (several nodes), a web application-based UI for DevOps process visualization, and connectors for integrating existing development tools such as GitHub and Travis. Iterations of this PoC were piloted across two development projects, as detailed in Section 4.

# Evaluation and Metrics

Software development teams track various metrics to ensure they achieve their project schedule, cost, and quality targets. Simultaneously, they manage project agility by measuring development productivity, velocity and other factors. **Fig. 3** above captures the Aricent Development Agility Metrics framework that serves as the basis for driving customer and business value.

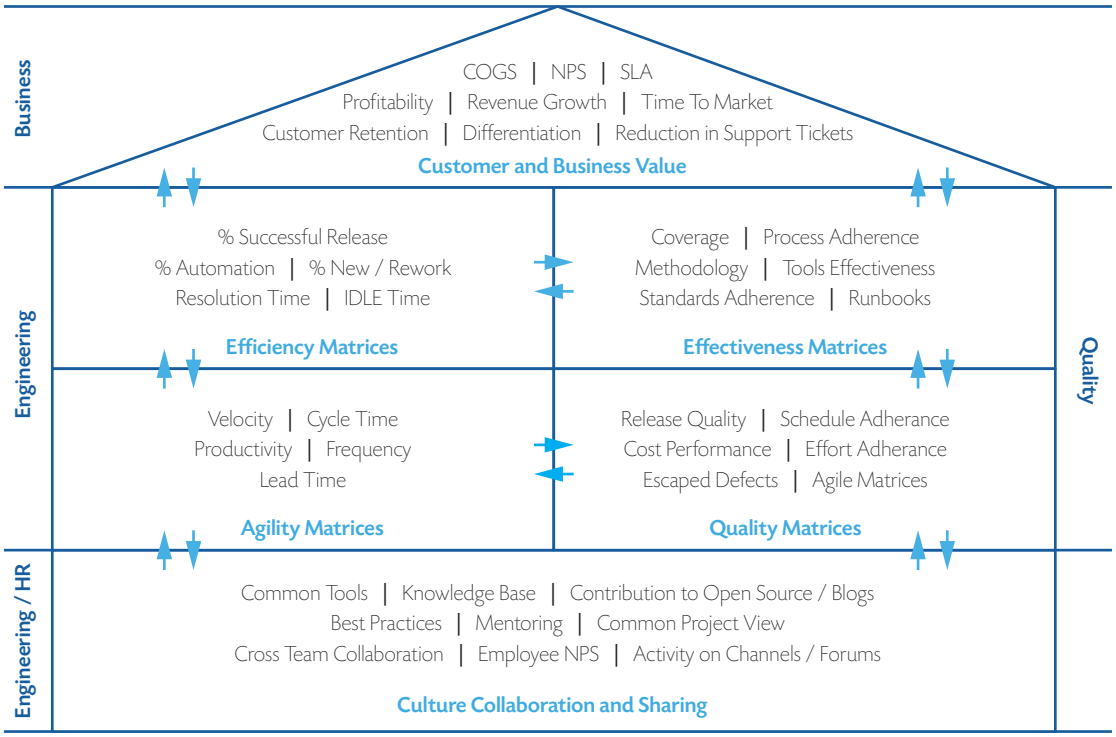



**Fig. 3. Development Agility Process Framework**

Engineering productivity is equally important for driving business value. **Fig. 4** highlights the key metrics across the five DevOps lifecycle phases.

| Development | Testing | Deployment | Release | Operate |
|---|---|---|---|---|
| - # LOC / Dev / Day<br>- # Commits / Day<br>- Wait time for Review, Pull Requests accept / reject<br>- New Development / Rework %<br>- Defect Closure Cycle Time<br>- # Code Smells<br>- Technical Debt (hrs)<br>- % of Successful Builds<br>- Build Frequency | - % Automated Tests Cases<br>- Code Coverage with Test Automation<br>- Wait Time to Test Environment<br>- BVT Test Cycle Time<br>- Regression Test Cycle Time<br>- Regression Test Frequency<br>- UI Test Cycle<br>- Security Testing Cycle Time | - Deployment Lead Time<br>- Deployment Frequency<br>- Deployment Duration<br>- Effort Per Deployment<br>- Infrastructure Preparation and Configuration Time<br>- Change Success Rate | - Release Frequency<br>- Time Taken Per Release<br>- Release Predictability<br>- Effort Per Release | - Mean Time to Recover<br>- Frequency of Outages<br>- # Ticket Closed / Weeks<br>- # Open Tickets<br>- Infrastructure Utilization<br>- System Health |

**Fig. 4. Engineering Productivity Metrics**

Validation of the hypothesis (Section 2) required establishment of pain points and success criteria. Framework and productivity metrics described above were foundational to this step, and measurable output from tools integrated in the PoC served to refine scope. **Tab. 1** details metrics and corresponding KPIs.

| DevOps Phase | Pain Point | Cause | Solution | KPIs |
|---|---|---|---|---|
| **Requirement Review**<br>**Code and Code Review**<br>**Code Coverage and Compliance Tests**<br>**Deployment**<br>**Monitoring** | Process latency in a multi-vendor or organizational working environment. | ▪ Multiple review cycles and feedback loops;<br>▪ Reviewer bandwidth constraints;<br>▪ Lack of transparency;<br>▪ Limited visibility;<br>▪ Email trails. | Project dashboard with continuous monitoring capabilities, reviewable by all stakeholders, and backed by private blockchain infrastructure. | ▪ **Defect Closure Cycle Time**[1]<br>▪ **Developer Efficiency**[2]<br>▪ **Pull Request Merge Frequency (Weekly)**[3]<br>▪ **Deployment Frequency**[4]<br>▪ **Deployment Lead Time**<br>▪ **Deployment Success Rate**<br>▪ **Release Package Success Rate** |
| **Build**<br>**Test** | Process bottlenecks or failures due to dependencies. | ▪ Critical test case failure<br>▪ Security check failure<br>▪ Open-source dependency check failure | Smart contract-based gating checks, via a private blockchain implementation. | ▪ **Build Success Rate**<br>▪ **Security Test Cycle Time**<br>▪ **Lost Cycles for Environment Tests** |

**Tab. 1. Project Phase – KPI Correlation**

1 Average time taken to restore service or resolve a defect
2 Full-time employee utilization
3 Number of requests merged to master daily
4 Release frequency a new version of a specific product or service as measured by number of deploys per month, week, day or hour

These KPIs provide a holistic view of time taken for each development phase and identify latency in each phase and steps. This allows us to implement optimizations strategies and improve build quality, which in turn improves agility and productivity. **Tab. 2** shows how the KPIs can be used to reveal inefficiencies so that product management can take timely action.

| PoC KPI | Case for Expected Latency Improvements | Conclusion: Actions to Take |
|---|---|---|
| ▪ Bugs Fixed per Week (Defect Closure Cycle Time)<br>▪ Pull Requests Merged per Week | **Review Cycle Duration / Number of reviews per week**<br>A low value may indicate multiple review cycles (loops) for every merge or an insufficient number of reviewers in the team. | Product management is notified that an increase in workforce may be necessary. |
| ▪ Build Success Rate<br>▪ Security - Scan Verification Speed | **Successful Builds per Week**<br>A drop in these KPIs may indicate that open-source or new security issues have been introduced into the product. | Product management is notified regarding blockers / issues. |

**Tab. 2. Determination of Workflow Improvement Steps**

Having defined KPIs to measure, the PoC developed was piloted on two production-grade software development teams at Aricent between December 15, 2017 and January 12, 2018.

## Project 1

A project in the security domain that focuses on development of new versions and features of a software framework, as well as enhancements and bug fixes for existing clients. The team consisted of an average of 14 people – varying between 12 and 16 overall, and engaged in Agile development. The sample size for (pre-pilot) metrics was two months – leading up to December 15, 2017.

| Metric | Bug Fixes | Developer Speed | Developer Contribution | Qualitative Observations |
|---|---|---|---|---|
| Baseline | 5.07 | 0.17 | 1.89 | 1 Reported improved collaboration between developers, tester, and tech lead. |
| Post-Blockchain (Raw) | 6.34 | 0.30 | 3.15 | 2 Skew in pull requests merged towards sprint end. |
| Delta (Raw) | + 25 % | + 76 % | + 67 % | |
| Delta (Normalized) | + 11 % | +33 % | + 29 % | |

**Tab. 3: Project 1 Metrics**

## Project 2

A project in the telecommunications domain that focuses on maintenance of, and bug fixes for, existing versions of a software framework utilized by numerous clients. The team consisted of an average of 27 people – varying between 13 and 41 overall, and engaged in Agile development. The sample size for (pre-pilot) metrics was two months – leading up to December 15, 2017.

| Metric | Bug Fixes | Developer Speed | Developer Contribution | Qualitative Observations |
|---|---|---|---|---|
| Baseline | 7.714 | 0.034 | 0.487 | 1 Reported improved collaboration between developers, tester, and tech lead. |
| Post-Blockchain (Raw) | 9.231 | 0.061 | 0.665 | |
| Delta (Raw) | + 20 % | + 79 % | + 37 % | |
| Delta (Normalized) | + 9 % | +34 % | + 16 % | |

**Tab. 4: Project 2 Metrics**

## Analysis

Blockchain utilization had a positive impact on both projects – quantitatively and qualitatively as described above. Given numerous project dynamics in play, it is impractical to attribute raw changes (improvements or declines) directly to the use of blockchain. Accordingly, numerous factors influencing projects were examined in detail to best distill the impact of technological and process improvement gains – including those attributable to the PoC. These included:

- Changes in team size and composition;
- Vacation schedules;
- Customer release schedules;
- Process deviations;
- Sample size deviations.

> **" The results exceeded our expectations and when fully deployed will provide new market opportunities, improved profitability and further differentiation from our competitors. "**
> **Walid Negm, CTO, Aricent**

In addition to observations attributed to each project, the PoC team observed additional value through blockchain in the form of:

- Improved collaboration by project teams resulted in higher issue resolution;
- Productivity gains partially attributable to developers knowing they were tracked and measured against set criteria;
- Immutable records of software development events provided a trusted data source for deriving stakeholder productivity metrics;

- Basis for establishing best practices that can be applied to additional projects;
- Identification of process inefficiencies resulting from a lack of personnel – e.g. pull requests typically merged towards the end of a development cycle (by approvers) even though developers/testers have completed feature development or bug fixes well in advance.

Further accuracy and attribution to technological and process improvements can be attained by increasing the sample size or data collection window, tuning the system based on team feedback, and incorporation of additional capabilities – as discussed in Section 5.

# Future Initiative

Looking to the future, we intend to develop a more robust solution, including new feature addition. **Tab. 5** lists of features approved at a brainstorming session in mid-December, which incorporated early project feedback.

| | Framework | Infrastructure | Settings |
|---|---|---|---|
| **Must Have** | — Modularity<br>— Prebuilt connectors<br>— Custom Workflows<br>— Edit Workflows | — Authentication<br>— Project Dashboard | — Exonum Dashboard<br>— Blockchain Explorer |
| **Good to Have** | — Connector parameters<br>— Extended connection options<br>— Custom step parameter capturing<br>— Templates, Workflow saving | — Notifications<br>— Data Isolations<br>— View Layer | — System Performance<br>— Validator List Extension |
| **Wow!** | — Visual Flow Builder<br>— Workflow lifecycle specification (versioning)<br>— Modularity, workflow references<br>— Combine projects | — Advanced Analytics<br>— Refined UI/UX | — DB Sharding |

**Tab.5: Prioritized New Features for Solution Enhancement**

This was augmented with project manager feedback to improve the overall look and feel:

- Dashboard consisting of multiple projects and KPI trends over the past 24 hours
- Hierarchical or layered view, wherein clicking on trends or reported anomalies allow for viewing detailed graphs/metrics that assist with root cause analysis
- Ability to approve or reject actions in batches
- Integration with JIRA (popular project management tool) to show task/issue/bug details alongside the approval process

| Capability | Value Add |
|---|---|
| **Strict Policies** | Tool configuration modifications require adequate permissions or multi-party consensus. Important in distributed development environments. |
| **Tool and Ecosystem Abstraction** | Blockchain as a 'hypervisor' between developers and tools. Single interface for code commits, test suite management, and test acceptance; operations visible to all stakeholders. |
| **Open-Source Compliance** | Legal as a stakeholder to whitelist open-source for incorporation. Unapproved packages will fail build or deploy processes. |
| **Automated, Trusted Releases** | Immutable ledger for in-order execution verification. Step-based acceptance for all phases ensures releases can proceed without manual intervention. |
| **Immutable Change Requests** | Smart contracts ensure unambiguous, mutually-agreed upon change requests. |
| **Licensing and Billing** | Automated and blockchain-based |

**Tab.6: Blockchain Value Adds for Productivity Gains**

**" Working with Aricent and DSCI, we were able to improve a system, provide unparalleled efficiency, and increase security. We look forward to seeing these results replicated by other companies as blockchain technology becomes even more widely adopted. "**

**ValeryVavilov, CEO of Bitfury**

As we continue to pursue efficiency gains within software development environments, and seek improved taaaaaransparency into software supply chains, it is important to remember 'why blockchain?' throughout further solution development. A few reasons are detailed above (**Tab. 6**), and serve as inspiration for the future.

# Appendices

# 1 Blockchain and Exonum Applicability

The use of blockchain technology is motivated by:

— **Tamper Resistance.** Through linked timestamps and periodic anchoring, blockchain can prevent tampering with the stored data. It is impossible to add, modify or delete data from the blockchain retroactively, which ensures a reliable audit trail. Blockchains are already used in security-critical environments, for example by Guardtime. Achieving a comparable level of tamper-resistance without blockchain requires expensive specialized hardware.

— **Consensus in Distributed Environments.** One blockchain-based design goal is to provide reliable consensus in a distributed, decentralized environment, where parties may not fully trust each other or some may act maliciously. In the proposed solution, blockchain provides a reliable middleware layer to DevOps systems and design a newly 'centralized' data silo from scratch. Compared to alternatives, blockchain requires substantially weaker security assumptions because implementations are trusted even in "hostile" environments.

— **Smart Contracts.** Blockchain technology can enforce formally specified DevOps workflows through smart contracts. This guarantees internal data consistency and reduces the possibility of negligence and malfeasance. Smart contracts are flexible, extensible. and can be adapted as DevOps best practices evolve and business environments change. Smart contract logic may be implemented without a blockchain, however, a blockchain provides consistency guarantees and tamper resistance (i.e., smart contract logic cannot be circumvented) and a built-in audit trail.

The Exonum framework is used for the following reasons:

- **Transparency.** Exonum is oriented towards restricted universal read access and provides a higher level of transparency than competing frameworks.

- **Security:** Exonum provides a robust consensus algorithm that is:

  - Optimized for blockchain

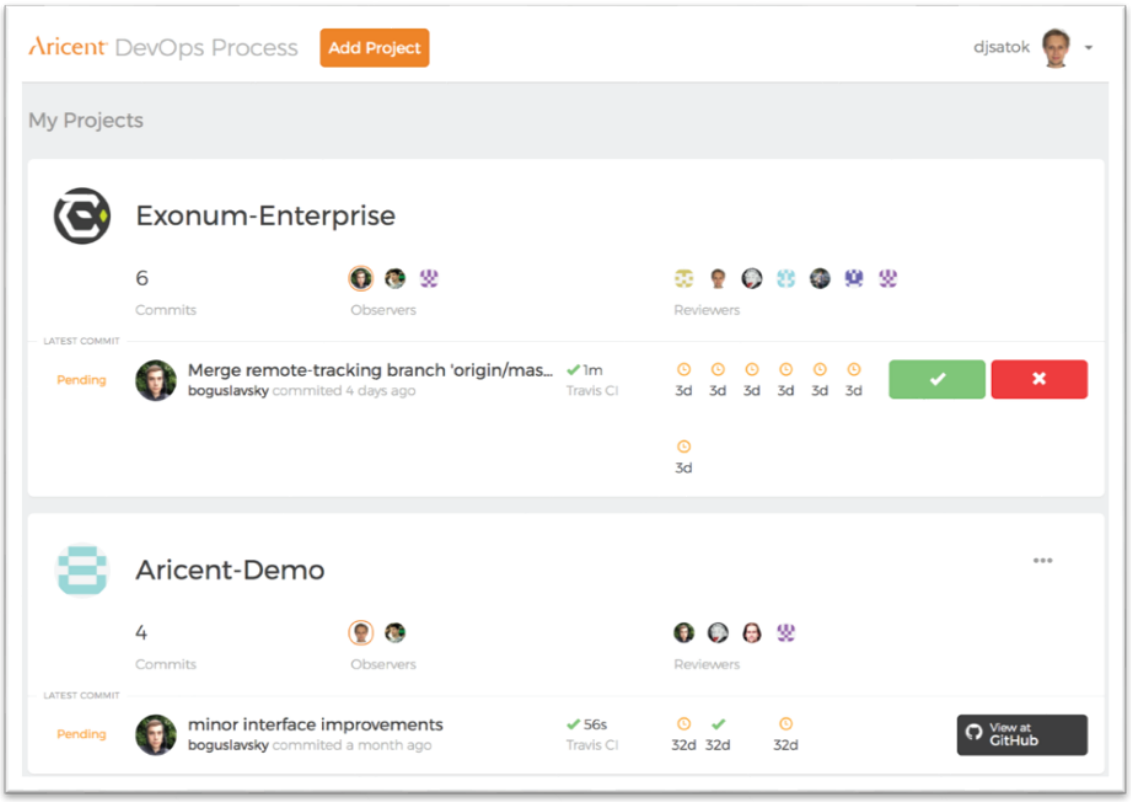
  - Resistant to malicious validator node attacks such as hacks or internal fraud attempts

  - Better performing in edge cases than algorithms implemented in competing frameworks. Exonum uses Rust, a programming language with rich static-verification capabilities to provide full memory and type safety.

- **Performance:** Exonum provides throughput of several thousand transactions per second per CPU core, which is higher than its competitors, due to Rust utilization.

## 2 PoC Sample Workflow and Screenshots

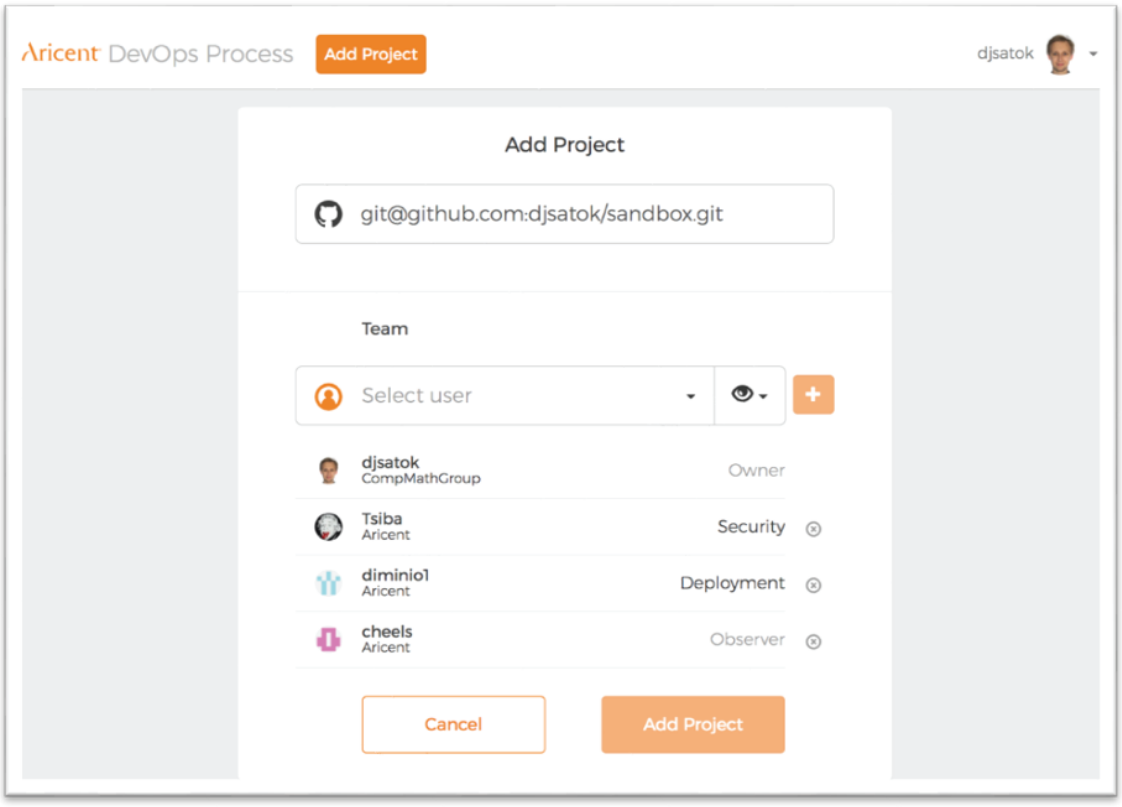
Project managers, developers, reviewers or observers can login to the web application via their GitHub/Bitbucket accounts or via private Git server credentials to view a summary page. They can access details of each repository build, add a new project or delete an existing one.



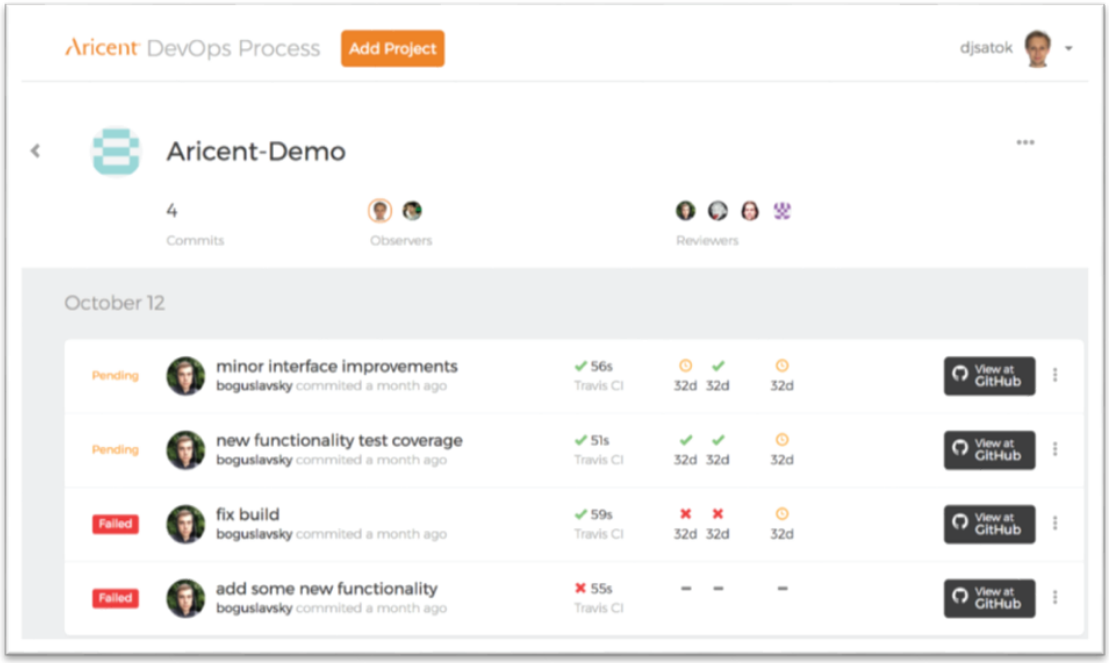

- To add a project, a user must specify the workflow for their development processes. In the PoC stage, we considered a single workflow for all repositories, which consists of one or two automated stages and several manual stages. These stages are:
  - **Code development.** Adding a new commit to the master branch on a public GitHub, Bitbucket or private Git repository;
  - **[Optional] Automated testing.** Building a repository and doing all the necessary automated checks and testing in Travis, the continuous-integration tool

- **[Optional] Manual testing and checks.** Manual approvals from the code review process, integration tests, deployment and security checks

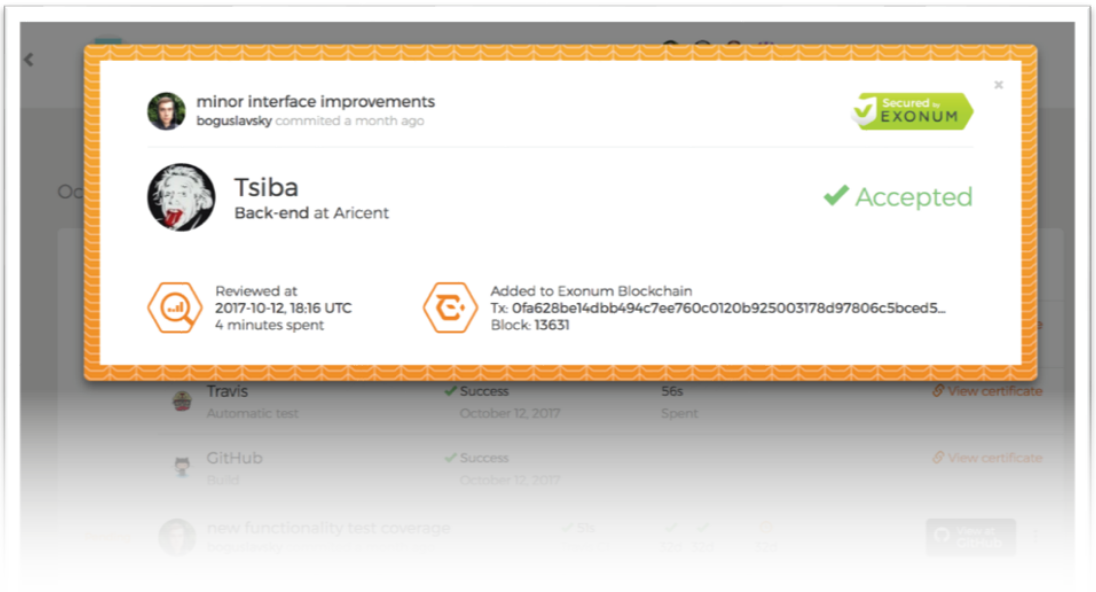
- A user can add observers to a repository, which represent auditors of the development process:



— A user can access build details and status for each repository:




— A user may navigate to confirmation or cancelation transaction details such as the timestamp by clicking on a status icon. The corresponding transaction validity certificate will be displayed if the cryptographic proof returned by the blockchain backend is valid.



# 3 PoC Timeline

| Step | Description | Duration | Intermediate Deliverables |
|---|---|---|---|
| 0 | Requirements documentation and system integration plan. | **(Prior to Start)** | Preliminary Requirements Specifications. |
| 1 | **Modeling**<br>Defining data, transaction, threat, role models; and preparing cryptography specifications. | **1.5 weeks** | Models and cryptography specifications |
| 2 | **Design**<br>UI, Smart Contract, and Backend design. | **3 weeks (parallel to Step 1)** | Web Application UI Mockups<br>Intermediate application version<br>Unit test suites. |
| 3 | Component Integration. | **1 week** | Integration test suite. |
| 4 | Deployment / Testing and Discovery.<br>Blockchain infrastructure deployment and training of key users. | **1 week** | |
| 5 | Defining entire project scope and presentation materials. | **2 weeks (parallel to Step 4)** | Scope for a comprehensive solution, and preparation of technical/marketing collateral. |
| **TOTAL** | | **6 weeks** | |

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