A framework for strategic intra- and inter-organizational adoption of the blockchain technology (July 2017)

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***Abstract*—Blockchain is a technology with disruptive, transformative and even revolutionary power [1], but currently its application faces many barriers: technological, governance, organizations and societal [2]. A significant amount of knowledge from both the blockchain and related fields is available, but there is currently no comprehensive application-ready methodology guiding organizations through their blockchain adoption journey. This publication provides a framework based on two fundamental concepts: inclusion of blockchain in current Enterprise Architecture as a requisition of safe and non-disruptive adoption, and coverage of the entire Adoption lifecycle, rooted in dynamic nature of blockchain as an ecosystem technology. Furthermore, this work covers the concepts of Evolutionary and Revolutionary development of blockchain-enabled solution.**

***Index Terms*— Adoption, blockchain, canvas, ecosystem, enterprise architecture, framework, lifecycle.**

I. Introduction

The idea of a chain of blocks connected by a hash function was formulated by Haber & Stornetta [3] more than 25 years ago, but there was no production-ready application of this technology until 2008, when a (group of) person(s) with pseudonym Satoshi Nakamoto conceptualized blockchain in the whitepaper "Bitcoin: A Peer-to-Peer Electronic Cash System" [4].

While blockchain is placed by Gartner [5] at the Peak of Inflated Expectations with the Plateau of Productivity expected to be reached by 2021 - 2026, it already deserved attention of tech experts and business executives as a technology with "disruptive," "transformative" and even "revolutionary" power [1]. Furthermore, in the sense of impact and evolution path, blockchain is commonly compared with another disruptive technology – the Internet protocol suite TCP/IP (including, but not limited to [2], [6], [7], [8]).

Application of blockchain technology faces many barriers: technological, governance, organizational and societal [2]. At the time of this writing, there is no formal framework that assists organizations in overcoming these barriers.

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The objective of this publication is to provide a blockchain agnostic[1] framework facilitating the application of blockchain within organizations in a manner complementary to established Enterprise Architecture frameworks.

II. Background

A. Blockchain

Blockchain is a distributed ledger that records transactions in a verifiable and permanent way [2]. This definition summarizes a set of essential properties, where the enterprise is currently fascinated about. The list below incorporates concepts from Zhu [9], Qian & Shen [10], and Christiansen [11], as well as my own insights, and summarizes the key properties of the blockchain technology:

1. *Distributed / Decentralized* – there is no central authority governing and maintaining the blockchain. Each full node owns a copy of the entire chain, and data is shared through a peer-to-peer network;
2. *Immutable / Unalterable / Permanent* – once a valid transaction is included into a block, and the network has reached consensus about the new state of blockchain, nor the transaction, nor the block could be altered. Immutability is ensured by the hash function, binding successive blocks together, and by the consensus algorithm;
3. *Trustless / Credible / Tamper-Proof* – blockchain is byzantine fault tolerant. Trust in individual parties is replaced by trust in the honest majority that will reject illegitimate transactions or blocks initiated by a malefactor. This property also enables value transfer on blockchain (through elimination of potential double spending);
4. *Transparent / Auditable* – each blockchain node has insight into all the blocks and transactions on the blockchain (although, part of the information, that is not involved into consensus process, might be encrypted).

B. Enterprise Architecture

Compatibility with the established Enterprise Architecture (EA) is a prerequisite for safe and non-disruptive adoption of blockchain by enterprise. Therefore, the framework adopts appropriate layers in order to ensure this compatibility. The

[1] Generic; not limited to a specific blockchain implementation.

Enterprise Architecture layers constitute the first dimension of the framework.

Winter and Fischer [12] have designed a generic structure representing the majority of Enterprise Architectures. It includes the following layers:

- *Business layer* – business strategy viewpoint;
- *Process layer* – organization of services in the relevant enterprise context;
- *Integration layer* – organization of information system components in the relevant enterprise context;
- *Software layer* – software artifacts, e.g. software services and data structures;
- *Technology (or Infrastructure) layer* - computing / telecommunication hardware and networks.

In order to provide a straightforward compatibility with the layers of blockchain solution stack, the lower three layers are slightly altered in compliance with Dinh, et al. [13] [2]:

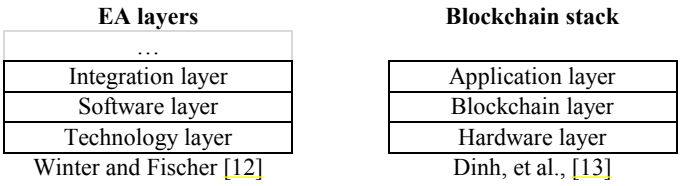

Fig. 1. Enterprise Architecture layers and the blockchain stack.

The Application layer represent the utilities containing business logic and being faced by the end-user; the Blockchain layer – consensus, data model, execution engine [13], protocols and interfaces; the Hardware layer – infrastructure and computing resources. A metaphor of the SPI model, standing for Software – Platform – Infrastructure [14], might help to visualize the blockchain stack.

As blockchain is an ecosystem technology exceeding the boundaries of a particular organization, an extra layer should be added to represent the context where the organization is located. The GRAAL framework (Guidelines Regarding Architecture ALignment) – a reference framework of the University of Twente – proposes "Enterprise environment" as a layer of enterprise context [15].

C. Ecosystem technology

Blockchain belongs to the category of digital ecosystem technologies - standardized digital platforms for a mutually beneficial purpose [16]. It exceeds the boundaries of a particular organization, enabling trustless and temper-proof cooperation between multiple parties.

As observed by Ruokolainen, Ruohomaa, & Kutvone [17], conventional Enterprise Architecture approaches are not straightforward applicable to ecosystems. By reason of their dynamic nature, ecosystems cannot be captured by a static snapshot.

The abovementioned observation is also relevant in the context of the blockchain technology. Blockchain's adoption success relies heavily on organization's ability to govern the ecosystem. A solution of this governance issue is proposed by Ruokolainen, Ruohomaa, & Kutvonen [17] – a life cycle view, allowing to cover the enterprise's current and future states.

D. Adoption lifecycle

Lifecycle is the second dimension of the framework. In this study, the lifecycle is represented by four major phases (based on [18], [19], [20]):

1. *Discovery* – initial stage, including, among others, exploration, feasibility study and strategizing;
2. *Implementation* – development or purchasing of the blockchain solution, followed by integration; redesign of current business processes;
3. *Operations* – regular use and maintenance;
4. *Disposal* – phasing out the solution (commonly in favor of another one).

III. Related Work

In order to evaluate the current state of affairs in research into application of blockchain within organizations, publications (e.g. journal papers, conference papers, books and digital articles) were collected using two categories of sources: scientific databases and search engines for publications.

Scientific databases	Publications search engines
1. ACM Digital Library	1. Google Scholar
2. IEEE Xplore Digital Library	2. Leiden University Libraries
3. ScienceDirect	3. Microsoft Academic
4. Springer Link	4. Semantic Scholar
5. SSRN	

Fig. 2. Publication sources.

Diversity of sources decrease the chance that relevant publications are omitted. Use of search engines (that are in general less strict in filtering) provides additional insights into non-peer-reviewed publications, for instance those related to industrial practices.

The search for publications is performed using a predefined set of related key words and combinations of these key words: adoption, application, blockchain, distributed ledger, enterprise architecture, framework, implementation, operations, organization.

The majority of publications on blockchain falls within one of the following categories:

[2] There are several classifications of blockchain layers. For instance, the classification of Mougayar [25] makes distinction between (1) Infrastructure and Protocols, (2) Middleware and Services, and (3) End-User Applications. This classification is more appropriate for permissionless (public) blockchains (e.g. Bitcoin and Ethereum), and not for permissioned (private & consortium) blockchains (e.g. Hyperledger and Monax), as the majority of consortium blockchain include the required middleware in the standard enterprise offering, making distinction of middleware and services as a separate layer irrelevant for organizations.

a. Exploratory studies, describing general properties, incentives, potential benefits and use cases of blockchain.

b. Studies focused solely on Bitcoin and not on blockchain in general;

c. Visionary papers, covering macro-economic and political aspects (e.g.: world citizenship, government as a service, sharing economy, and the fourth industrial revolution);

d. Studies focused on technical aspects of blockchain.

A small number of publications focuses on (inter)organizational application of blockchain, but limited to:

a. A very specific topic (e.g. discussion of the role of reengineering leaders);

b. A brief overview of diverse topics without building an exhaustive model.

The following table provides an overview of related work (in alphabetical order by author's last name) together with a short remark concerning the content of publications.

Publication	**Relevant content**
Blockchain as Radical Innovation… [20]	"Blockchain Innovation Process"; building competencies to rethink current business models.
Blockchain in financial services: Regulatory landscape and future challenges… [21]	Position of authorities on distributed ledgers; Main regulatory challenges; Technological challenges; Operational challenges.
Digital Supply Chain Transformation... [22]	Blockchain principles and functionalities within Digital Business Ecosystem (DBE) framework
Blockchain and Business Process Improvement. [23]	Business Process Improvement; Value-Driven Business Process Management (VBPM).
Business Innovation Through Blockchain… [24]	Value system, Governance and Security of blockchain; Blockchain-Enabled Enterprise Systems; Business innovation practices.
The Business Blockchain… [25]	Catalyst-Barrier-Solution framework (a framework for focusing blockchain's success). Decision-Making model (rationality of blockchain adoption).
A maturity model for blockchain adoption. [19]	Blockchain Maturity model; Stages of safe adoption procedure.

Fig. 3. Related work.

IV. FRAMEWORK

A. Framework canvas

As already stated previously, the framework canvas – a high-level representation of main concepts and a fundament for further use-case specific elaboration – consists of two axes: vertical, representing various (generic) layers of Enterprise Architecture (EA), and horizontal, representing the adoption lifecycle.

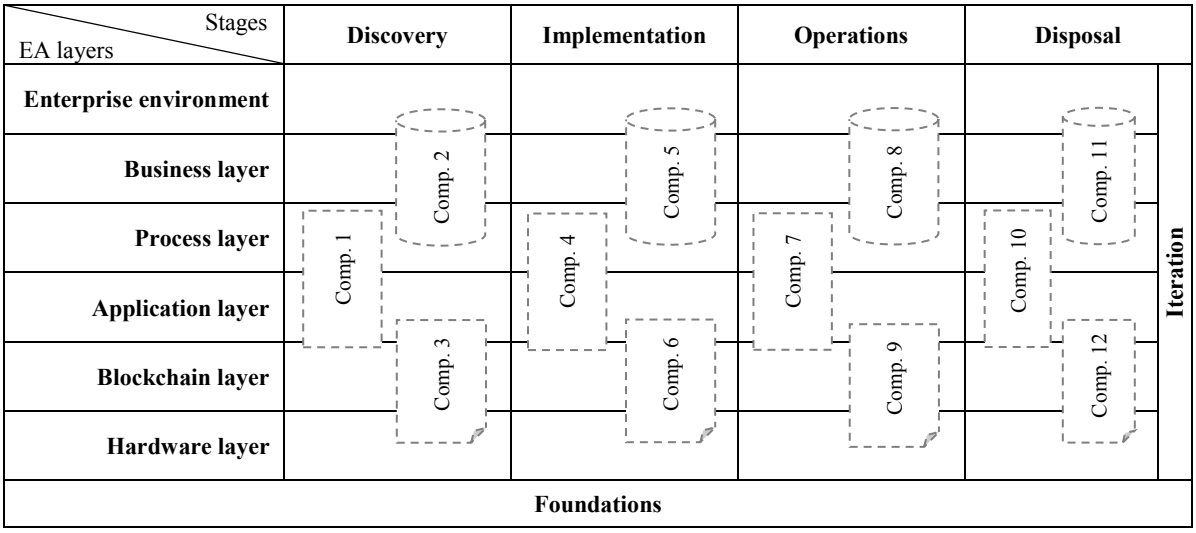

Fig. 4. Framework canvas.

Each "cell" provides guidelines within the context of a certain Enterprise Architecture layer in a certain phase of adoption lifecycle. The exact content of each particular item might differ, when appropriate addressing one of the following aspects:

- Stakeholders and their responsibilities;
- Goal or challenge;
- Methodology or activity;
- Deliverable or milestone;
- Reference standard building block.

An additional category – Foundations – provides insights into fundamental aspects that are relevant regardless of the EA layer and the lifecycle phase.

In drawing up the framework an attempt is made to keep it generic. The intention is to provide an appropriate components composition and depth level regardless of the organizational structure and maturity, readiness to change, urgency and scope of the project.

This provides a generic canvas applicable for any setting of strategic blockchain adoption, it is up to the organization to decide on a right composition and depth of particular components.

B. Evolutionary & Revolutionary cycles

In order to facilitate sustainability and development of enterprise, the framework incorporates two iterative concepts: cycles of evolution and revolution.

The Evolutionary cycle takes place within the context of the Operations phase. Its main purpose is to ensure appropriate reaction of Business and Information infrastructures on both internal and external threats and opportunities emerging over time.

The Revolutionary cycle facilitates sustainability and growth of the organization in cases when a gradual and continuous improvement process could not deliver an appropriate pace of change. A few examples of events that might trigger the need in revolutionary development are: fundamental transformation of the enterprise environment, radical change of involved stakeholders, technological development (not compatible with the current ecosystem, but providing significant benefits).

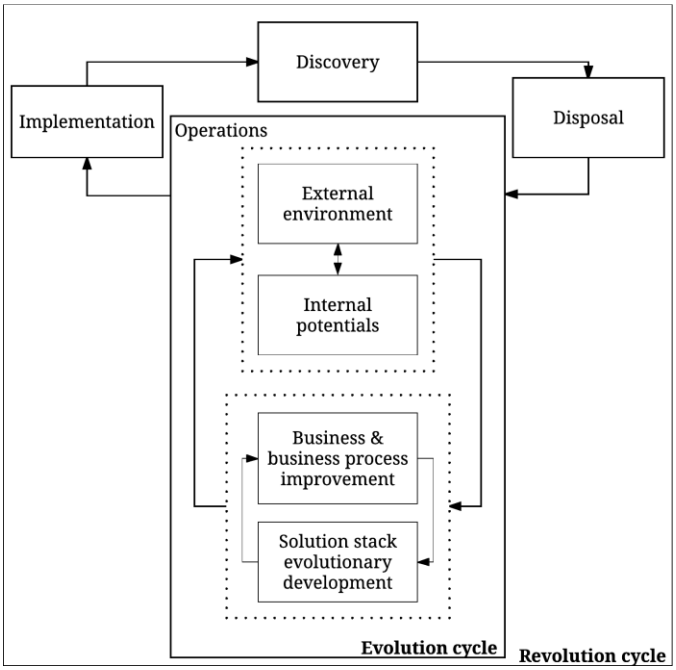

Fig. 5. Evolutionary and revolutionary cycles

C. Reference components composition

This chapter provides a reference composition of relevant components. The aim of reference composition was to keep the setting generic, not focusing on a particular industry, organization size, type of relations within the business network, and level of urgency.

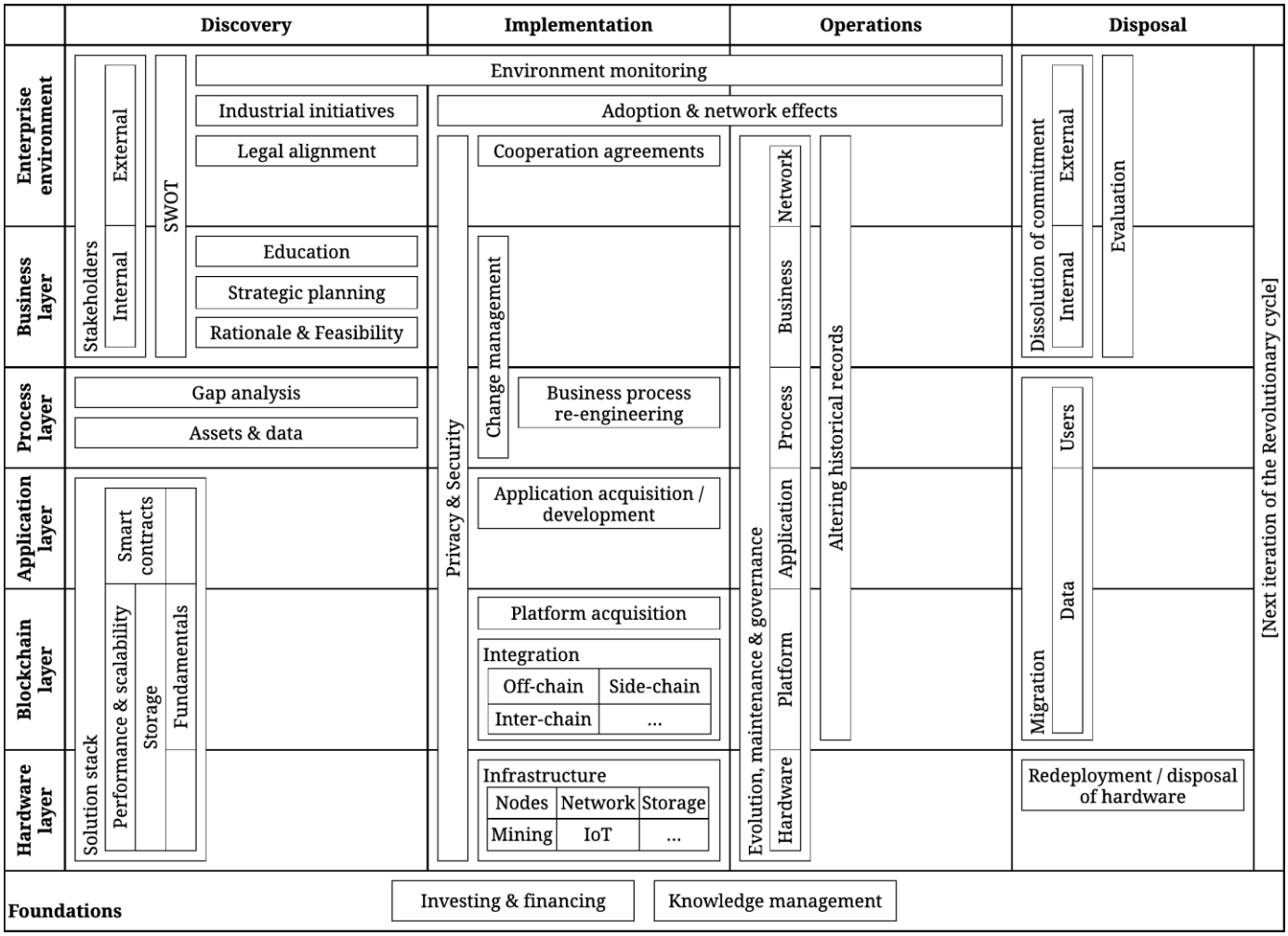

Fig. 6. Reference components composition.

When the framework with reference components composition is applied by an organization, two steps should be undertaken:

a. A pre-selection of components should be considered, as the complete reference catalogue exceeds the reasonable needs of an average organization.

b. Adding supplementary components should be considered, as the reference catalogue may lack certain (industry specific) elements.

V. Conclusion

Blockchain technology follows an evolution path similar to TCP/IP and might eventually reach a comparable adoption rate, becoming the value exchange protocol of the Internet. While blockchain has not yet reached a mainstream adoption, individual organizations willing to adopt this technology will need an elaborative guidance. This framework for strategic intra- and inter-organizational adoption of the blockchain technology provides a generalizable groundwork for a tractable adoption of blockchain.

While the framework canvas is fundamental and universally applicable, the reference components composition has some limitations due to a trade-of that was made between generalizability and applicability to a specific use-case. The reference components composition implies a heavy overhead when applied in a small-scale project, and might lack important industry-specific elements when applied in large-scale.

A further (applied) research might focus on elaboration of framework components compositions for projects of different scale and different industries.

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Since April 2013 **Artem I. Kharitonov** follows developments in the blockchain sector. Among others, he closely observed the collapse of Mt. Gox in February 2014 and the hack of TheDAO in June 2016. Those unfortunate events aroused his interest in further exploration of the blockchain technology.

In October 2016, he decided to conduct research into the adoption of blockchain as a graduation project for his master study ICT in Business at the Leiden University.

This publication summarizes a few important concepts from his graduation paper.