A Business Ecosystem Architecture Modeling Framework
Confidential draft version

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***Abstract*—The concept of enterprise architecture (EA) introduced in the 1980s refers to business-IT alignment in a single organization. The concept has proven its utility in the practice of IT management, but EA frameworks cannot deal with network organizations that are enabled by IT. EA frameworks assume a hierarchically coordinated organization, where final responsibility for strategy rests with management. The characteristic feature of network organizations is that there is no central coordinator with final responsibility. Yet, today's network organizations are facilitated by IT and they too must be aligned with their IT infrastructure.**

To align networked organizations, we must take the value viewpoint, which is absent in EA. This paper presents an approach to business-IT alignment for networked organizations based on the concept of networked value models. In addition, since there is no hierarchical management in a network, we view business-IT alignment in a network as a coordination game, and we include results from coordination theory and game theory in our approach. We illustrate our approach with an example from the electricity business and apply it to the Bitcoin network.

***Index Terms*—Business ecosystem; enterprise architecture**

I. Introduction

The concept of an enterprise architecture (EA) has been introduced by Zachman in the 1980s to help align the different viewpoints involved in developing an information system [1]. Today these viewpoints have evolved into three groups called *layers*: The business layer of business strategy and business operations, the technology layer of applications and software infrastructure, and a physical layer of equipment, facilities and physical networks [2], [3].

EA frameworks such as the TOGAF assist organizations to align their IT with their business [4]. They recommend steps dealing with organizational strategy and architecture governance that assume a central management that is responsible for decisions about business-IT alignment in their organization. Section II-A provides more information about the assumption of central governance in TOGAF.

The assumption of central governance makes EA frameworks like TOGAF unsuitable for network organizations that do *not* have a central coordinator. Since the 1990s there has been a rapid growth of network organizations, facilitated by the internet, web technology, mobile technology, RFID and the Internet of Things. Today this growth continues under the influence of blockchain technology, big data and machine learning. All of these technologies allow companies to outsource some of their value activities to third parties, to bundle products with complements, to offer online platforms to producers and consumers, to buy information-intensive services from others, and to decentralize their organizations [5], [6], [7].

These networks have no central governance. Each member of the network has its own business goals and legitimately looks after its own interests. Each member has the freedom to do something else. Nevertheless, these networks are IT enabled and some form of business-IT alignment is needed. How can we achieve business-IT alignment in that context for the entire network?

The core idea in solving this puzzle is to exploit the fact that each member of a decentral network will look after its own interests. We unpack this fact in four steps. First, to get an architectural view on the network, we use Moore's metaphor of an business ecosystem [9] and Brandenburger & Nalebuff's view that members of an ecosystem play a so-called *coopetition* game. In this game, participants compete and cooperate to create value for themselves [8] (section II-B).

Next, to understand the decentralized nature of business ecosystems and coopetition games, we use results from coordination theory to identify the dimensions of decentralized coordination (section II-D).

Third, to represent the fact that each member of ecosystem, or more precicely each player of the coopetition game, looks after its own interests, we use the e^3*-value* method to model the exchange objects of value (services, goods, money or experiences) among participants [10], [11]. In the coordination game, each player will have a value model of the ecosystem (section II-E).

Finally, we use known work in requirements engineering to map the architecture of the ecosystem to the required technical infrastructure. This gives us *The Business Ecosystem Architecture Modeling* (TEAM) framework, described in section III. We illustrate the framework with an application

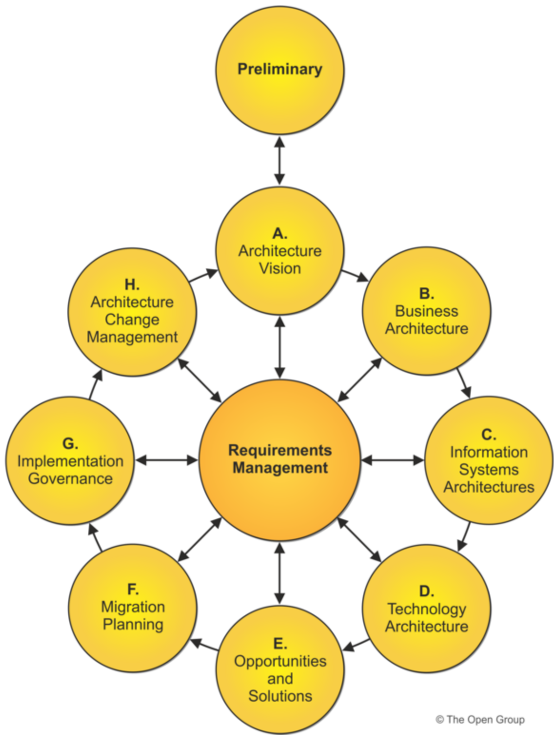

Fig. 1. Architecture Development Method of the TOGAF EA framework [4]

to the electricity distribution ecosystem, and present a larger example by applying it to the Bitcoin ecosystem in section IV. Section V discusses related work and section VI discusses what we have achieved and indicates topics for further work.

Our contribution in this paper is to integrate different frameworks for the analysis of ecosystems, coopetition, coordination and value models into a model of decentralized business-IT alignment with a decentralized governance game.

Our research methodology is analytical. We analyzed coordination models and business ecosystem models and integrated them into a framework. To test the validity of the framework we have applied it to a number of our past case studies and to the Bitcoin ecosystem.

II. Background

A. EA Frameworks

We here briefly support our claim that EA frameworks cannot be used in networks. Consider the dominant EA framework today, the TOGAF standard Architecture Development Method (ADM) [4].After a preliminary stage, this iterates over a number of tasks, starting with formulating an architecture vision and ending with architecture change management (figure 1). In the preliminary stage a hierarchical governance is set up. Responsibilities for the various steps are are defined, measurement frameworks set up, etc. After migration to the new architecture, in step G, ADM specifies a governance task for the implementation process, which is hierarchical too. It assumes defined roles and responsibilities for the architecture team, a budget for governance, a central architecture repository, etc.

In steps B, C, D and F of ADM, the ArchiMate language can be used to specify the business strategy and motivation, the business, information systems, technology architectures, and the implementation and migration plan [3]. The concepts defined in each of these steps have a meaning in hierarchies but not necessarily in networks. For example, the ArchiMate concepts of *resource, capability* and *course of action* refer to resources, capabilities and courses of action of the company that strategic management is responsible for.

Business-IT alignment in organization networks is a coordination game, and we next summarize results from coordination theory that we will use in our TEAM framework.

B. Business ecosystems

Today's organizational networks are facilitated by IT. The internet, the web, mobile technology, RFID, ad hoc sensor networks, blockchain, and the Internet of Things all create opportunities for network organizations in which there is no central coordination. At first, these technologies have facilitated outsourcing, but in addition they have also made it possible to grow by buying services online from other companies. Standardization has made it less risky to engage in long-term relations with suppliers and partners [5]. At the same time, big data and machine learning push decision power down in an organization, by which a centrally organized business gets more decentralized [7, page page 121 ff.].

This means that businesses and their environment turn into business ecosystems. The concept of *business ecosystem* has been introduced by Moore in the 1990s [9]. It refers to the collection of suppliers, customers, competitors and other stakeholders that coordinates their activities to produce goods and services for customers (figure 2). Customers are members of a business ecosystem too.

As shown in figure 2, from the point of view of one company, some suppliers supply complementary products. Brandenburger & Nalebuff [8] call these businesses *complementors,* defined as actors whose product makes your product more valueable for customers. For example, Microsoft is a complementor of Intel. We view financial stakeholders such as banks and venture capitalists as suppliers (of money) to the company of interest.

From the point of view of one company, its customers, suppliers, competitors and complementors play a game to create value for themselves (figure 3). They select suppliers, cooperate with complementors, and distinguish themselves from competitors, cooperate with competitors to define define standards, etc. Brandenburger & Nalebuff call this the coopetition game [8]. Coordination in decentralized business ecosystems takes the form of a coopetition game, and we will use the guidelines of Brandenburger & Nalebuff in our TEAM framework.

Comparing Moore's view of ecosystems (figure 2) with the coopetition diagram (figure 3), we see that business ecosystems contain two more kinds of actors:

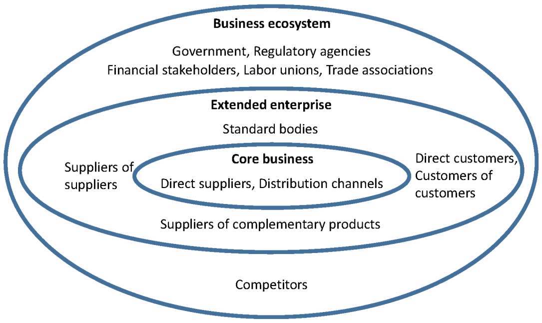

Fig. 2. Participants in a business ecosystem [9].

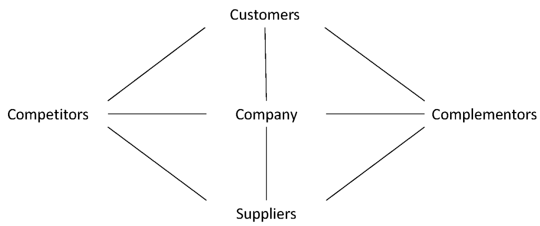

Fig. 3. Players in the coopetition game [8].

- *Rule makers,* such as government organizations, regulatory agencies, and standard bodies. These actors define the normative context of the game. They may over time change this context, and they may even be influenced by the players to change it. But they are not part of the coopetion game in which products are bought and sold. Note that the players themselves are also rule makers. They negotiate and sign contracts, which are the rules by which players agree to interact with each other. This is part of the game of coopetition.
- *Associations,* such as trade associations and labor unions, special interest groups, professional conferences, fairs, etc. Associations provide mechanisms by which players of the game of coopetion communicate.

To sum up, the players in a business ecosystem are organizations (hierarchies) that play the coopetition game within the bounds set by rule makers and who communicate through associations.

C. Why business ecosystems?

Why should a company need to understand its business ecosystem? A negative reason is that if a company focuses entirely on optimizing and innovating its products, it will not notice it if the ecosystem loses ground and is outcompeted by another system [9]. To put it positively, true innovation requires a business to change its ecosystem.

A related reason is that many companies would like to be the Amazon of their ecosystem [20], [21]. To fulfill that ambition, they need to understand their ecosystem. If they improve their ecosystem, they can offer new products and access new customers at a lower risk than would otherwise have been the case.

A third reason is that to thrive in a decentralized system without hierarchical governance, a company needs to play the game of coopetition, which requires understanding its ecosystem.

Finally, related to the issue of business-IT alignment: Today business ecosystems are facilitated by new technology, from the internet and web to mobile technology, wireless sensor networks, the Internet of Things, big data, machine learning, and autonomous devices, all of which works towards decentralized ecosystems. On top of that, new regulations, such as the new EU payment services directive PSD2, force organizations to open up to competitors. All of these technological and legal developments turn the question of business-IT alignment at the ecosystem level into the question how a business can exploit new technology by innovating its ecosystem.

D. Coordination theory

We will get a better understanding of the coopetition game if we view it as a form of coordination. Coordination theory stands in the tradition of transaction cost theory, in which the question is asked why there are enterprises at all [12], [13]. Why not buy all the products you need from a market? The answer has to do with the cost, benefit and risk of producing a product in-house versus obtaining it from a market [14]. From a coordination point of view, this is an assessment of the cost, benefit and risk of coordinating in a *hierarchy* (ai.e. an enterprise) with central governance, or in a *market* with no central governance.

In addition to the coordination paradigms of hierarchies and markets, Ouchi [15] added a third coordination paradigm, which he called a *clan.* In markets, actors coordinate through price, in hierarchies they coordinate by business rules, and in clans they coordinate by tradition. Enterprises accept management authority, but in clans actors accept the authority of common, traditional, values and beliefs.

Ten years later Powell [16] picked up the stick, using the terms *market, hierarchy* and *network* for the three coordination paradigms. In Powell's analysis markets coordinate by price, hierarchies by routines, and networks by relationships.

In his analysis, Powell uses an analysis of contracts by the legal scholar William Macneil [17], [18]. Briefly summarized, and simplifying the legal niceties, Macneil defines a contract as an agreement of two or more parties to coordinate their activities. Macneil compares two kinds of contracts, that he calls discrete and relational. In a *discrete contract,* the identity of the parties to the contract is irrelevant, and a transaction is specified, in which commodities are exchanged, for example a bottle of soda against €2. The contract is completely specified, all parties to the contract are assumed to know all the consequences of the contract, and the transaction is treated as atomic. In case of conflict, one resorts as much as possible to written specifications other than the contract. Examples of discrete contracts are contracts in spot markets and the stock

	Discrete market	Hierarchy	Relational network
Coordination mechanism	Price	Business rules	Shared norms & values
Legitimate authority	Written specifications	Management	Tradition
Reciprocity	Fair exchange	Fair salary	Visible acknowledgement of one's contribution
Method of conflict resolution	Haggling, resort to court	Management decision	Maintaining relations & reputation
Contracts	Written, complete	Written, incomplete	Agreement to shared norms & values
Mutual trust	Low	High	Very high
Anonymity	High	Low	Very low
Switching cost	Low; standard interfaces	High	Very high; relation-specific interfaces

TABLE I
DIMENSIONS OF COORDINATION

market.[1]

At the other extreme is the relational contract, where the parties are identified as members of the same community and exchanges of products are not specified at all. The contract itself may be unwritten, much like the hypothetical social contract that members of a society have with each other. The relational contract, whatever its form, does not specify what is to be done, but specifies agreement with a set of norms and values. What is to be done is not specified in the contract but is to be found elsewhere, and written specification are the last think one looks at to find this out. The first source of information about what is to be done is tradition.

Van Alstyne [6] provides an extensive literature survey of network organizations, viewing them as collections of decision processes, collections of rational agents, and as collections of people who share a tradition. He identifies many dimensions of coordination.

Combining and rationalizing the dimensions of coordination provided by Ouchi, Powell, Macneil and Van Alstyne, we get the list in table I. Comparing discrete markets with relational networks, we see that discrete markets coordinate through price and perform transactions according to complete and written specifications. Transaction must be perceived as fair by all parties to the transactions. The parties may be anonymous and mutual trust is low. It takes little effort to transact with a competitor, because interfaces are standardized.

In relational networks, by contrast, actors coordinate by shared norms and values and accept the authority of tradition. One's contribution must be acknowledged visibly in a way that is determined by tradition. Contracts may be unwritten and only specify membership of the community and hence agreement to shared norms and values. Conflicts are resolved by reinstating relations and respecting reputation. All participants are known and mutual trust is high. It takes a lot of effort to break up a relation and build it up with someone else.

Discrete markets and relational networks are opposites in all dimensions, and yet they share a property that sets them apart from hierarchies: there is no central coordinator in them. Hierarchies are coordinated by business rules set by management. Tasks are performed against a salary and conflicts are resolved by management decision. Employment contracts are incomplete, for they only specify the employee's role, and not what the employee should do at a particular point in time. Henceforth we refer to discrete markets and relational networks as *network organizations* to set them apart from hierarchies.

We should add that in practice, any organization has a mix of the features of all three kinds of coordination. The important characteristic that we will focus on is the presence or absence of a central coordinator and, hence, the possibility or impossibility of central governance.

The dimensions of coordination in table I will return in the TEAM framework. Henceforth, we speak of the coordination game among participants in an ecosystem, but we will use the term "coopetition" if we want to emphasize that the participants coordinate with a view to creating value for themselves.

E. e^3-value

To play the coopetition game in a business ecosystem, participants must have a view of the allocation of costs, benefits and risks across actors in the ecosystem. For this we use the *e^3-value* method, which we developed in the past 20 years to help organizations design end evaluate e-commerce business models [10], [11], [22]. It has been tested in, amongst others, case studies in the music business [23], energy [24], [25], health care [26], [27] and aviation [28].

An *e^3-value* model represents players in the coopetition game and the commercial transactions that they are engaged in. The *e^3-value* diagram in figure 4 shows a company that obtains the components of its product from the same supplier that its competitors do, but enriches it with a complement from a complementor. For example, it may sell wine obtained from the same importer as its competitors do, but sells it to its customer bundled with a bottle opener.

Each business in the diagram has a *value activity,* represented by a rounded rectangle. A value activity is an activity that may create profit for the business that performs it. A

[1] One is reminded here of the concept of smart contract in blockchain — except that these contracts are not necessarily smart, and they are not legal contracts [19].

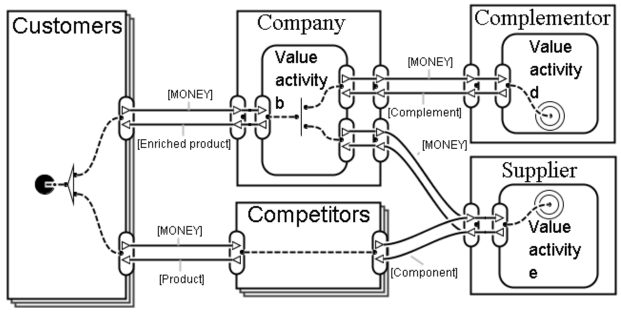

Fig. 4. An e^3-*value* diagram with all five kinds of players

business engages in one or more value activities. For each of these activities, it may decide to outsource it, i.e. to allocate it to another actor and buy the resulting value object from that actor. It is by its value activities that an ecosystem player adds value to the system.

Actors in a value network exchange *value objects,* which may be goods, services, money or experience (such as music). Value objects are visible in the diagram as labels of value transfers.

The oval interfaces of an actor collect reciprocal value transfers. Reciprocity means that each party to a transaction perceive the transaction as beneficial to itself. Reciprocity can be quantified if we make assumptions about the monetary value of a value object. Of course each member of the value network may make different assumptions, so that their view of the value network comes with different quantifications. However, the money flows in the diagram will have, by definition, the same value to the sender and the recipient of the money.

The dashed lines connect a customer need (represented by a bullet) to boundary elements (represented by bull's eyes) through an acyclic and/or graph, called a *dependency path.* In the example, the customer can choose between buying an enriched product from the company or a plain product from its competitors. Boundary elements limit the scope of the game. For example, we may enlarge the scope by including the players from whom a supplier buys the products it needs.

Each transaction in a value network is atomic. To explain this we need to introduce the concept of a *contract period:* Each value model represents interactions among business actors for a period of time, such as a month, a year, or a longer period of time. Atomicity of transactions means that if a consumer need occurs in a contract period, then all transactions in its dependency path occur in that contract period.

Apart from the contract period, there is *no* sense of timing in the diagram [29]. The dependency path indicates that an occurrence of a customer need implies the occurrence of the commercial transactions of the dependency path of this need, according the the and/or logic of the path. This is precisely enough to estimate cash flows in the model. An e^3-*value* model is also silent about data storage or IT needed to perform these transactions.

e^3-*value* is supported by tools in which one can simulate scenarios with different market assumptions about occurrences of consumer needs, price of value objects, and investments per actor, to estimate revenues and expenses for the actors in the model. This allows sensitivity and financial risk analysis. In addition it contains notations and supporting tools to generate fraudulent scenarios to assess fraud risks. These have been described elsewhere and we will not repeat that here [30], [31].

III. The Ecosystem Architecture Management (TEAM) framework

The TEAM framework consists of nine sets of questions about the architecture of the ecosystem and three sets of questions about the decentralized business ecosystem architecture, grouped in three layers: strategic view, value modeling view, and technology view (figure 5). Answering the questions the three architectural layers creates an overview of business-IT alignment in the ecosystem architecture.

We view decentralized governance as a coordination game, that we have grouped in similar layers: strategic, tactical, and technological. Answering the coordination questions assists in playing the decentralized coordination game.

A. Strategy layer

The strategic view of a company on an ecosystem it participates in, is concerned with the *customer needs* to be satisfied, and with the *participants* of the ecosystem. As explained in section II-B, the participants are the suppliers and complementors who the company needs to satisfy those needs, competitors who try to do the same, and the rule makers that provide boundaries and and associations that provide communication mechanisms for the participants of the ecosystem.

Having identified customer needs and participants, the third concern is to assess whether each participant *adds value* to the system. Each player has capabilities to perform value activities, but for any actor its capabilities are limited. Value activities that contribute to the satisfaction of customer needs must be identified. This is essential for playing the coopetition game [8] and also a necessary preliminary for the value modeling task at the tactical level.

When modeling an ecosystem as-is, we must identify the value activities that the participant actually deliver. When redesigning an ecosystem, a participant may decide to re-allocate them by outsourcing, or to bring in new value-adding participants.

Thus, the strategic architecture of an ecosystem consists of participants who perform value activities to meet customer needs.

As explained before, in the TEAM framework we view decentralized governance as a coordination game. To play this game, participants must consider coordination paradigms (table I). Decentralized coordination may be market-based using only price as coordination mechanism, but more likely

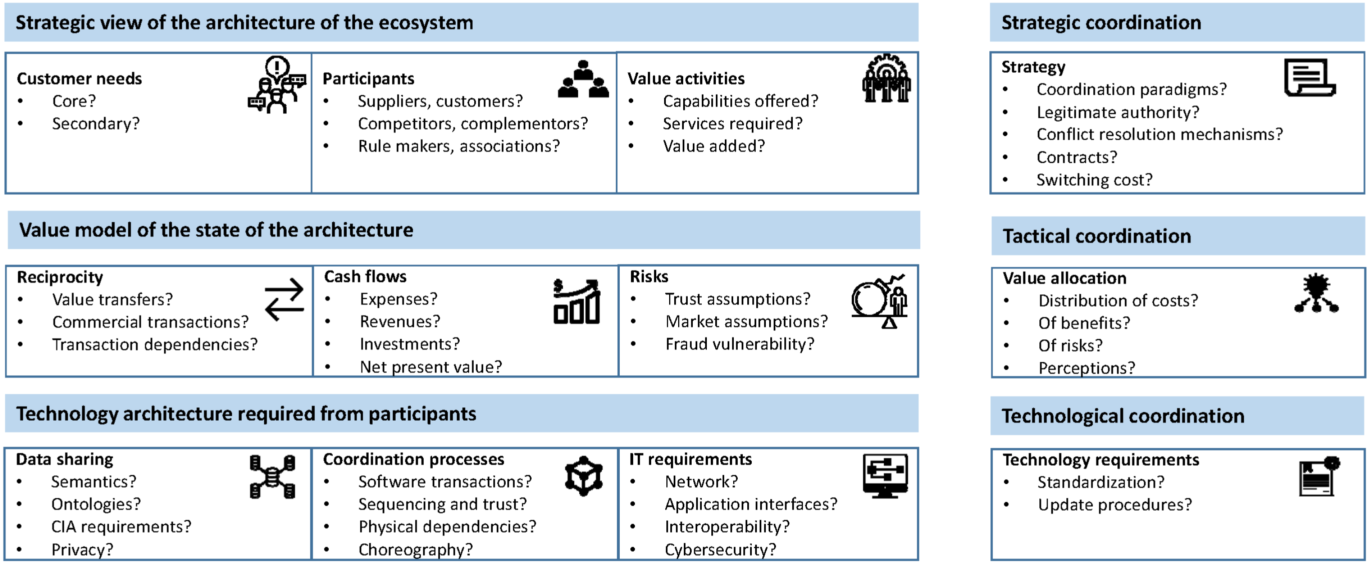

Fig. 5. The Ecosystem Architecture Management (TEAM) framework

there will also be a relational paradigm based on shared norms and values. And there may also be some hierarchy in the sense that some participants are more powerful than others.

Stepping through table I, a participant should consider the source of legitimate authority (written agreements such as the law and contracts, the force of tradition, or a mix of them), and mechanisms to resolve conflicts. Written and unwritten agreements must be considered, and the cost of switching to another transaction partner must be assessed. This is influenced by, among others, the level of standardization in the ecosystem, which is a technical governance game.

The normative environment created by rule makers, and formal and informal communication mechanisms created by associations, provide the boundaries and mechanisms with which to achieve a company's goals in the ecosystem. Some of this can of course be influenced by the players of the game.

Example. Gordijn & Akkermans [24] present a case study of the Norwegian electricity supply system, which is mostly based on hydropower. The study explores the possibility to evolve this ecosystem into one where small-scale hydropower installations owned by farmers and other land owners would generate electricity for the electricity grid.

The ecosystem satisfies the *need* for affordable green energy that can cope with the expected growth in demand. *Participants* and their *value activities* are

- end users who need electricity,
- the projected hydropower equipment owners who generate electricity,
- suppliers of equipment to these local producers,
- electricity suppliers who deliver electricity to end users,
- distribution system operators that provide distribution, metering and billing services to end users, and
- transmission system operators who provide balancing services to the distribution operators.

Rule makers are the Norwegian government and the European Union, and standards organizations such as the European committee for Electrotechnical Standardization and the Smart Grid Coordination Group. Examples of associations are the International Hydropower Association and the International Energy Agency.

Coordination of the system will be mostly market-based. Government policy prescribes low switching cost for end users.

B. Value model

The viability of an ecosystem is determined not only by the extent to which it meets customer needs, but also by the perceived fairness of the distribution of cost, benefits and risk over the participants. If players become aware that costs are made by one set of actors but benefits are reaped elsewhere, then the system may disintegrate.

The bottom line though for any ecosystem is that each player must have positive revenue. To assess this we build an e^3*-value* model that consists of a map of commercial transactions, such as the one shown in figure 4, and checking it for reciprocity of all transactions. In terms of the value network, *reciprocity* means that there must be no transaction where all value flows in one direction only.

In addition, if we quantify money flows, we can simulate *cash flow* scenarios based on assumptions about customer need and prices, and we use the tools to assess *risks,* such as financial risks and vulnerability for fraud. We do not go into details here as they have been described elsewhere [35].

Each player in the system can make a model like this, and

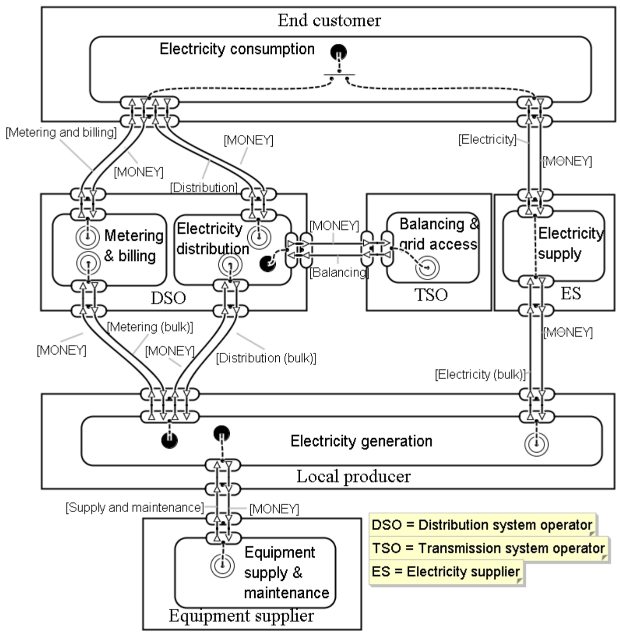

Fig. 6. Value network of an electricity ecosystem

in their negotiations they may share some parts of their own value model of the ecosystem with others.

> *Example.* Figure 6 shows the e^3-*value* model of the commercial players for small-scale hydropower generation in the Norwegian electricity ecosystem. We see that at this more detailed level the top-level need has decomposed in four needs (represented by black bullets). The end customer needs electricity, which is satisfied by the electricity supplier and DSO. The DSO needs balancing services, which it obtains from the TSO. The local producer of electricity local equipment to generate electricity, and needs the distribution and metering services of the DSO to distribute the generated electricity to consumers.
> All value exchanges are *reciprocal,* and simulations show that *cash flows* can end up positive for all players [24]. Simulations show that costs, benefits and risks are distributed in a viable manner.

C. Technology architecture

At the technology level we need to look at *data sharing* requirements across participants. For example, a semantics must be agreed for shared data, and confidentiality, availability and integrity requirements must be specified on data that is accessed cross-organizationally. If transactions are automated, agreements must be made on who validates them, if valid transactions can be refused (censored), and on finality of transactions. (A transaction is final if all participants can be sure that it occurred.)

Players need to agree *coordination requirements* about transaction details and the coordination process. We have published guidelines for the design of a coordination process from a value model earlier [32], [33]. These guidelines have to do with trust assumptions, physical movement of goods, and therefore these questions should be asked when analyzing existing or designing new coordination processes.

IT requirements that follow from the network may be application interoperability requirements. Also participation in an online network creates cybersecurity risks, and these must be analyzed.

Technological coordination is concerned with IT standards chosen for the network, and update procedures that players agree among each other.

> *Example.* The study reported by Gordijn & Akkermans [24] does not report data sharing, coordination or IT requirements. However, any technical implementation of the value network must include data sharing requirements such as confidentiality, and define processes for billing and metering.

IV. Example: Bitcoin

As a second example, we apply the TEAM framework to the Bitcoin network. An excellent introduction to Bitcoin is given by Antonopoulos [36].

A. Strategic view

- *Consumer needs* are [37]
  - P2P payment,
  - Anonymity and
  - Absence of censorship (all valid transactions must be finalized).
- *Participants* and their *value activities* are:
  - Clients who engage in payment transactions;
  - Core developers who develop and update the Bitcoin protocol;
  - Miners who store the blockchain, validate transactions, and finalize them, and are rewarded for this in bitcoins;
  - Mining pools who offer risk spreading to miners;
  - Validators that validate and store transactions;
  - Hardware suppliers that supply wallets to clients,
  - hardware suppliers that provide computing equipment to miners, pools and validators;
  - Exchanges who change bitcoins against fiat money;
  - Banks who provide payment services, e.g. to pay exchanges and other suppliers.

  All of these players are also rule makers because they can formally or informally enter into agreements specified in contracts. In addition, there are other rule makers, notably governments. The Bitcoin philosophy is to avoid the grasp of governments, but nevertheless all participants live in a jurisdiction and are responsible to it. For example, banks and exchanges must be licensed.

  Finally, there are associations through which members coordinate. Examples are
  - https://bitcoin.org/en/download for the Bitcoin Core source code,

– https://github.com/bitcoin/bips/ for Bitcoin Improvement Proposals,
– https://www.reddit.com/r/Bitcoin for discussions among developers, and
– a legion of Bitcoin conferences (e.g. https://www.coindesk.com/bitcoin-events) and
– blogs (e.g.https://medium.com/topic/cryptocurrency).

The entire ecosystem is large and has fuzzy boundaries, but there are a few well-known core developers and a few well-known miners.

- The *coordination game* is complicated, because we find mechanism both from the discrete market form of coordination and from the relational network kind of coordination. We discuss each of the coordination dimensions of table I.
  – The *coordination mechanism* is partly based on shared norms and values of Bitcoin core developers, who value privacy highly and distrust banks and governments. This has a background in the libertarian Cypherpunk movement [38]. On the other hand, miners, mining pools, exchanges, and manufacturers of dedicated mining hardware use price as their coordination mechanism.
  – The libertarian background of some Bitcoin developers means that they do not accept *legitimate authority* of government. On the other hand, the commercial players, i.e. the miners, pools, exchanges and banks, live in jurisdictions where they have to, and mostly do, accept the legitimate authority of the government and its written laws.
  – *Reciprocity.* Bitcoin developers live in a world of open source software where credits are given for one's contribution, and reputation is an important asset. The commercial players aim for fair deals, and may even speculate with bitcoins to acquire sufficient income [39].
  – *Conflicts* in the developer's world are resolved by discussion, and if not resolved, may lead to hard forks in the protocol. In any case, developers produce software residing in github. It is up to the miners to use this software, and they will have commercial considerations when making this decision. This frustrates many attempts to improve the protocol [40]
  – *Contracts:* In the developers world, contracts are partly written agreements on which you stake your reputation. In the commercial world of the miners, pools, exchanges and banks, contracts are formal and written.
  – *Mutual trust* seems to be low among all players, although among core developers trust is higher. Trust between clients of the payment network can be absent, as this is one of the goals of the Bitcoin Payment protocol.
  – *Anonymity:* Clients in the payment protocol are near-anonymous, as they identify themselves by pseudonyms that they can change per transaction. The commercial players are known and identified, as are most core developers.
  – The *cost of switching* within the payment network is zero: any two clients in the Bitcoin network can engage in a payment transaction. The cost of switching to another cryptocurrency network is higher, as one has to buy the other cryptocurrency.
    Miners invested large amounts of fiat money in hardware to do mining (i.e. to validate and finalize bitcoin transactions) and cannot switch to a system where other mining algorithms are used. This explains their resistance to new consensus algorithms.
    Developers too pay a large cost when switching to another ecosystem. Core developer Mike Hearn left the Bitcoin Core development group in 2015 to work for R3, a consortium of banks, to develop the Corda system. In a post on Medium, Hearn had to defend himself against the many attacks by developers, who viewed this as a move to the enemy [41].

It is clear that the commercial players play a different game than the developers. This makes decentralized coordinaton of the Bitcoin ecosystem nearly impossible. On top of that, the developers game is nearly impossible to play too, as its members do not take kindly to the idea of following anyone's rule but their own. For example, before leaving Bitcoin, core developer Mike Hearn attempted to create a hard fork of bitcoin to resolve an issue with block size. The admin of the bitcoin.org disagreed with this hard fork and blocked any post to the discussion forum mentioning it [41].[2]

B. Value model

A value model of the Bitcoin network that shows *reciprocity* of transactions among players, and models *cash flows* in the period 2012-2016, has been presented elsewhere [42] and we will not present it here. That paper shows that hardware and energy costs for miners have increased to a point wherein the long run, it is not profitable to be a miner. In time, this will undermine the viability of the Bitcoin ecosystem.

There are other *risks* too. The Bitcoin ecosystem is vulnerable to fraud, errors and hacks at the edges of the system: in the wallets used by clients, and in exchanges that are not as rule-governed as banks.[3]

The *value governance game* is an unequal one: Some early investors in bitcoin have become millionaires [43], whereas many others, who bought expensive in 2017, have a lost a lot of money.

C. Technology architecture

The technology architecture of the Bitcoin network is well-defined [36]. All bitcoin payment *data is shared* in a single blockchain, that is replicated across all miners and full nodes.

[2]https://www.reddit.com/r/Bitcoin/comments/3rejl9/coinbase_ceo_brian_armstrong_bip_101_is_the_best/cwoc8n5/

[3]https://www.abitgreedy.com/cryptocurrency-hacks/

There is no privacy in the sense that all blockchain data is visible to anyone, the addresses of the participants in a payment transaction are pseudonymous, so that clients can hide their identity.

The *coordination protocol* prescribes validation of a bitcoin transaction by all full nodes and miners [36]. The miners in addition guarantee noncensorship, as all valid transactions will eventually be added to the blockchain. And they guarantee finality, i.e. after roughly one hour it is infeasible for anyone to remove a transaction from the blockchain.

The requirements on full nodes and miners follow from the protocol and from the state of the blockchain. Over time, computation resources required for miners and disk space required for full nodes grow.

The decentralized *technology governance game* is subject to the troubles explained above, namely that developers and commercial players in the Bitcoin ecosystem play a different game and are not inclined to play the game that the other does. In addition, some developers seem to play a game without rules.

D. Lessons learned

Stepping back, we draw the following lessons about TEAM from this analysis:

- The TEAM framework allows the identification of white spots in our understanding of an ecosystem. For example, cryptocurrency textbooks neglect the commercial role of exchanges and banks and completely ignore the value model for the commercial players in the ecosystem. Yet, without a viable value model, a cryptocurrency network cannot survive in the long run.
- The TEAM analysis of the governance game at all three levels reveals properties that must be understood by anyone who wants to acquire added value by joining the ecosystem. For example, analysis of the Bitcoin governance game reveals that there are two sets of players who play a different game, that switching costs are high and that the distribution of costs, benefits and risks is very unequal.

V. Related work

Zachman [44] proposed the concept of a federated enterprise architecture for enterprise that consist of several business units. However, this is an approach on the technical level of our framework and it assumes central governance.

Coordination came to be studied as a topic in itself by Malone and Crowstone [45], [46]. However, they take a resource-driven computer science view of coordination, whereas we need an ecosystem view that includes commercial and relational coordination.

Houy et al. [47] propose an interorganizational abstraction in process modeling called ”BPM-in-the-large”, based on process mining. This might be useful for the definition of a coordination process in an ecosystem, which is an important activity at the technical level in some ecosystems.

Müller et al. [48] analyze the applicability of the TOGAF 9.1 enterprise architecture method and framework [4] to inter-organizational collaboration. They found that TOGAF 9.1 provides handles for starting to deal with challenges of integrating processes, data, application, and infrastructure, but that it does not deal with the organization of the entire network. We refine this last statement by concluding from our analysis that TOGAF does not deal with value modeling, strategy, and the governance game in ecosystems.

Drews & Schirmer [49] analyzed four business ecosystems on the role of EA. They found that neglect of the diversity of capabilities of participants caused problems, and that an unbalanced distribution of costs and benefits over participants of an ecosystem caused projects to fail. They also found that attention to relations of power and influence at the strategic level is crucial for success. They propose a progression of increasingly integrated EA levels, starting with the separate EAs of the participants of the ecosystem, leading up to a business ecosystem architecture that includes the infrastructure and interfaces of the entire network organization, including details of some of the local EAs.

None of these proposals include the value viewpoint, which is necessary to align the interests of independent actors. Also, all proposals assume some kind of central governance, where we propose a game approach to governance in decentralized networks. In addition, none of these proposals benefited from the insights in coordination theory acquired from the study of network organizations, as we do in table I

VI. Discussion and further work

The TEAM framework integrates results from of research in e^3*-value* and coordination theory, and business literature on ecosystems and coopetition. The TEAM framework contains all dimensions of coordination from table I. The strategic governance game considers almost all dimensions of coordination. Of the remaining dimensions, reciprocity is the main issue analyzed and quantified in the value layer. Mutual trust and anonymity are considered in the risk assessment (trust assumptions), coordination analysis and design, and also in cybersecurity requirements analysis. The value model is the key in the alignment of IT and strategy in a business ecosystem.

The two examples presented in this paper suggest that it can give insight in the business-IT alignment problem of network organizations and provides handles to understand and play the game of decentralized governance. More validation is needed, and we are currently involved in case studies to apply it to more real-world ecosystems. We are also updating current tool support for e^3*-value* to facilitate application of TEAM in the real world.

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