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# Fair is Fair: A Fair Value Distribution Mechanism for Cloud Manufacturing Ecosystems

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# Fair is Fair: A Fair Value Distribution Mechanism for Cloud Manufacturing Ecosystems

## Completed research paper


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## Abstract

Cloud Manufacturing is a manufacturing paradigm that focuses on collaboration and resource utilization. Until recently, little research has been done to combine the perspectives of cloud manufacturing and digital platform ecosystems. In the cloud manufacturing paradigm, the cloud coordinator takes up the dual role of a matchmaker and a platform owner, though, so it is interesting to research how any power dominance of the platform owner can be avoided. To do so, three dimensions of platform governance suggested by Tiwana 2014 – pricing policies, decision rights, and control – were considered in this contribution to recommend a fair value distribution mechanism for platform ecosystems in cloud manufacturing. Requirements for such a solution are formulated in this contribution and design patterns satisfying these requirements are derived. We propose using tokens administrated by distributed ledger technologies and smart contracts to enable a special split revenue scheme that satisfies the requirements for a fair value distribution and risk sharing within the contributing partners.


**Keywords** cloud manufacturing, fair value distribution, platform ecosystem governance, design pattern

# 1 Introduction

One aspect of the digital transformation of enterprises is to focus on the wishes of the customers even more than in the past (e.g., Gerster 2017; Reis et al. 2018). To be capable of reacting flexibly to customers' preferences, enterprises adopt ideas of open innovation (cf. Chesbrough 2003) and customer co-creation (e.g., Reichwald and Piller 2009). This requires handling a plethora of individualized offerings and the capability to shift to complex mass customization with small series, not seldomly with batch size one (Lasi et al. 2014; Roth 2016). Concentrating on core competences (cf. Prahalad and Hamel 1990), on the other hand, enterprises engage more in complex business ecosystems to cooperate in networks of value (Iansiti and Levien 2004; Moore 1993). For some scholars, customer centricity and customer co-creation result in a new service paradigm called service-dominant logic (e.g., Vargo and Lusch 2008), which means that enterprises always engage in value creation by offering services even when offering a product (good) as "goods are a distribution mechanism for service provision" (Vargo and Lusch 2008). Simply put, economics focuses on service provision, with product-focused industries increasingly changing their offerings and delivered services for their customers. One prominent example is Rolls Royce®'s Total Care® program and its to-the-point slogan "power by the hour."[1] Rolls Royce offers their engines as a pay-per-use service and improves maintenance and service time by using IoT technology and data science (cf. Choudhury and Mortleman 2018).

Following these assumptions, mechanical engineering businesses (such as those from the metalworking industries) try to conceptualize machine offerings as a service on their customers' shop floors.[2] However, payment models such as pay-per-use mean that the customer's entrepreneurial risk crosses over to the service provider insofar as the service provider suffers from low levels of capacity utilization but might not participate on high levels in the same relation. Thus, with offering pay-per-use models for machines, it is promising to regard the machine as an autonomous business unit and to enable it to offer its services on a larger market than a factory is. Cloud manufacturing (CM) conceptualizes such ideas (cf. Liu et al. 2019) and was introduced in 2010 (cf. Li et al. 2010). The idea of CM is to share manufacturing resources, such as machines or software from different enterprises (providers), and orchestrate them by a cloud coordinator to fulfill customer requests. The cloud coordinator acts as a platform that coordinates multi-sided markets (cf. Boudreau and Hagiu 2008) by selecting and scheduling the contributing resources. The goal of CM is to increase the utilization of manufacturing resources by means of sharing and business collaboration (cf. Liu et al. 2019). The platform, providers and customers together form a complex digital business ecosystem (cf. Hein et al. 2020; Schreieck 2020).

As a platform and market maker, the cloud coordinator is in a special position of power. Today, the majority of the world's most valuable companies, including Alphabet, Alibaba, and Facebook, are based on platform business models. These models allow a wide variety of entities (e.g., service providers, customers, and complementors) to mutually interact and transact for value co-creation (Schreieck 2020). The ecosystem participants have to be coordinated and regulated to generate collective value profitably and effectively. This task is performed by a matchmaker who forms the business platform. Such matchmakers are typically represented by one central platform owner, responsible for all regulation and coordination activities in the ecosystem. This platform owner exhibits a central position of power (Moazed and Johnson 2016).

In a vast number of cases, such an archetype of an unbalanced power relation w.r.t. the platform owner and participants leads to an unfair and disproportionate value distribution (Mattila and Seppälä 2018). Platform owners regulate their platform to maximize their own profit and not primarily to maximize the value of the overall ecosystem (Boudreau and Hagiu 2008). Successful ecosystem management therefore poses two questions: 1) How can value be created that attracts participants to engage in value co-creation; and 2) How can value be fairly distributed (Iansiti and Levien 2004; Rong et al. 2015). Value distribution in CM is an open research issue (Adamson et al. 2017; Liu et al. 2019). Wu et al. (2013) raise unanswered questions associated with the cloud (platform) coordinator: namely, how can the coordinator decide between different providers and how can value be measured to be distributed fairly. To address such questions, we search for a CM ecosystem governance concept and design patterns supporting that concept. Thus, we raise two research questions:

1) What are requirements for a CM ecosystem governance concept to enable a distribution of value fairly and according to the participants' risk?

[1] https://www.rolls-royce.com/media/our-stories/discover/2017/totalcare.aspx

[2] We discuss such concepts with the R&D representatives of TRUMPF (https://www.trumpf.com) and FESTO (https://www.festo.com/group/en/cms/index.htm).

2) Which organizational and technical design patterns can be applied to conceptualize the CM ecosystem governance concept according to these requirements?

The remainder of this contribution is organized as follows. The method section (section 2) reveals the research design, followed by the research problem and an elaboration of the requirements for the CM ecosystem governance concept (section 3). Section 4 presents design patterns which help to implement this governance concept. A conclusion with a discussion of limitations and future work completes this contribution (section 5).

# 2 Method

Striving for new business opportunities and transformational ideas, we approached representatives of the German machine manufacturers TRUMPF and FESTO to discuss a fair value distribution within manufacturing business ecosystems. In the future, we aim to develop an actionable governance concept enabling a fair value distribution in a platform-based CM ecosystem in cooperation with these partners through an Action Research (AR) approach (cf. Davison et al. 2012).

AR "focuses on change through interventions in an organizational context and enables the generation of both practical and scholarly knowledge" (Davison et al. 2012: p. 764). It is iteratively conducted in a cyclic process of five phases: 1) diagnosing, in that the problem is specified; 2) action planning, in that alternative courses of action are deliberated on a theoretical basis; 3) action taking, in that one course of action is organizationally and technically implemented; 4) evaluating, in that the consequences of action are studied and assessed; and 5) specifying learning, in that the findings are presented to the scientific and the practical audience (cf. Baskerville 1999).

This contribution expresses our focal theory for "action taking" (cf. Davison et al. 2012). Communicating this theory in advance of taking action is recommended to 1) inform the scientific community about the instruments for solving the identified problem; and 2) capture the theory explicitly for evaluating the instruments' usefulness after taking action (Baskerville and Myers 2004).

To develop the theory, we analyzed the literature to define requirements (section 3). To meet the requirements, we recommend design patterns elaborated in an argumentative-deductive approach (cf. Wilde and Hess 2007; section 4).

# 3 Research Problem and Solution Requirements

In this contribution, we research an ecosystem governance concept that enables a fair value distribution in CM platform ecosystems. Although CM is a well-researched concept with first implementations,[3] little is known about CM business concepts. Despite obvious existing architectural and organizational similarities between cloud manufacturing and platform ecosystems, both perspectives have not yet been fused. This is surprising, as Liu et al. (2019) describe the CM operation model as follows: "manufacturing resource providers register their resources to a cloud platform and the platform operator manages and operates the platform for providing manufacturing services to consumers" (p. 862). Thus, the role of a platform and its operator in the sense of a multi-sided market maker is well recognized. The platform operator governs the ecosystem, formed by interactions of providers, the operator and consumers. Business ecosystem governance essentially involves how a platform owner influences its ecosystem and is a major aspect of the architectural design of platforms (Hein et al. 2020; Tiwana 2014). Parker and Van Alstyne (2018) define governance as a set of rules concerning who gets to participate in an ecosystem, how to divide the value, and how to resolve conflicts. Our research problem is to find a governance concept that prevents the dominance of the platform owner over the providers within the CM context. Hence, we search requirements for such a governance concept and corresponding design patterns for its implementation to enable fair value distribution and good incentivization for all contributors in the CM ecosystem. To identify these requirements, we analyzed literature about CM and platform governance. The derived requirements are presented below.

## 3.1 Cloud Manufacturing

CM is defined as a "model for enabling aggregation of distributed manufacturing resources (e.g. manufacturing software tools, manufacturing equipment, and manufacturing capabilities) and ubiquitous, convenient, on-demand network access to a shared pool of configurable manufacturing services that can be rapidly provisioned and released with minimal management effort or service

[3] For reviews, see Adamson et al. 2017; Liu et al. 2019; Wu et al. 2013 and also http://www.indics.com.

operator and provider interaction" (Liu et al. 2019). It transforms manufacturing from being product-oriented to being service-oriented (Tao et al. 2011) and bundles resources of different organizations to dynamically compose service packages and bring them to the customer (Wu et al. 2013). The manufacturing cloud is controlled by a cloud operator who executes the governance system and has plenty of tasks, including task decomposition, searching, scheduling, invocation, or billing (cf. Adamson et al. 2017).

Layer models (cf. Figure 1) clarify the CM architecture (e.g., Adamson et al. 2017). The resource layer consists of manufacturing resources, such as machines, but also software or knowledge (Zhang et al. 2014). The perception layer abstracts these resources, enabling standardized communication with other components (Zhang et al. 2014). The service layer is responsible for describing the service, typically using semantic technologies such as the Resource Description Framework or ontologies (cf. Lu et al. 2014; Zhang et al. 2012). International standards are developed to ensure interoperability (e.g., BMWi (ed.) 2020). Once the resources are virtualized and encapsulated in services by the service layer, the middleware layer orchestrates the service delivery for application (Zhang et al. 2014). This orchestration consists of functions such as transaction management, cooperation management, or billing. From our perspective, the functions of the middleware layer are the most relevant ones for the cloud operator. **Requirement A-1**: The governance concept and its design patterns should fit the architecture of CM.

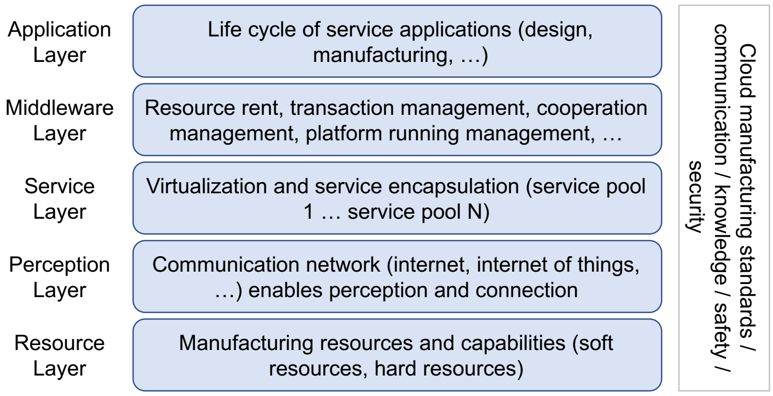


**Figure 1: Cloud manufacturing architecture (with changes from Zhang et al. 2014)**

## 3.2 Platform Governance

Tiwana (2014) proposes three dimensions of platform governance: *pricing policies, decision rights*, and *control*. As we aim to develop a platform governance concept, these dimensions guide us in structuring the concept. Following this, we derive further requirements for our concept from these dimensions.

### 3.2.1 Pricing Policies

Pricing policies define how the value created within the ecosystem is shared (Hein et al. 2020) as well as how and by whom prices are set (Schreieck et al. 2018). They describe the incentives that are used to attract the different market sides and encourage participation in the platform ecosystem (Tiwana 2014).

CM follows the service paradigm and is customer-centric (Adamson et al. 2017; Li et al. 2010; Liu et al. 2019). Thus, pricing changes to value propositioning and value is a collaborative process between providers and customers (Lusch et al. 2008). Moreover, an enterprise cannot deliver value but instead offers a value proposition, which the customer as co-creator can utilize to accomplish the value (Vargo and Lusch 2008). The beneficiary (customer) determines the value in the special context of co-creation phenomenologically and experimentally (Vargo and Lusch 2008). When the beneficiary co-determines the price of the co-created value, the strategy is called value-based pricing (cf. Cannon and Morgan 1991; Raja et al. 2020), which correlates positively with firm performance (Liozu and Hinterhuber 2013). **Requirement PP-1**: The pricing mechanism as part of the governance concept should support value-based pricing.

Wu et al. (2013) propose that all parties involved in a CM ecosystem must benefit from the venture and gain additional value by using CM. These authors call for a fair distribution of benefits as otherwise the contributors would not engage in the ecosystem further (Wu et al. 2013). The organization of such distribution is not discussed in the CM literature. **Requirement PP-2**: The value distribution mechanism as part of the governance concept should enable a fair value distribution for all contributors.

Fairness, in the sense of this contribution, means that contributors assess their input-outcome ratio against other contributors and feel fairness when the ratio of others is approximately the same. This idea of fairness expresses equity theory (Adams 1963). Individuals feel stress when input-outcome ratios are unequal and inequity exists (Huseman et al. 1987). **Requirement PP-3**: The distribution of value that the customer is willing to pay for should be in relation to the input of all contributors.

Taking entrepreneurial risk is a prerequisite for engaging in a venture (Marshall and Ojiako 2015). CM aims to enable collaboration between businesses to increase the operating grade of manufacturing resources (Liu et al. 2019). When businesses collaborate, it seems fair to share entrepreneurial risk among the network of collaborators. Consider this example: Provider A delivers an axle, provider B a gear wheel, and the connection and packaging are provided by C. Hence, C orders from both A and B and pays both products. Irrespective of the risk that the customer will pay or is satisfied, C pays A and B. Thus, A and B do not share the risk of the entire venture, but C does. It appears fairer that all involved parties receive their share of value only after the entire job is completed. **Requirement PP-4**: Value should be distributed when the customer pays for the service, so that involved contributors share risk equally to their input ratio.

### 3.2.2 Decision Rights

Decision rights regulate the autonomy of entities, i.e., who is allowed to make which decisions (Tiwana 2014). Keeping the discussed aspects of fairness in mind, an organizational setting that fosters fair decisions and hinders the power asymmetries of central platforms is required (Cutolo and Kenney 2020). It is preferable for all contributors of the stable core of the ecosystem (cf. Mattila and Seppälä 2018) to be involved in major decisions. **Requirement DR-1**: The platform owner, as a cloud operator, should be organized in such a way that all contributors of the ecosystem's stable core are allowed to co-decide.

Entity autonomy refers to the degree of freedom actors have when co-creating value on the digital platform and can be either high or low (Hein et al. 2020). "High autonomy complementors refer to a loosely coupled relationship in which the complementor is independent and separate from the digital platform" while "low autonomy complementors are tightly coupled strategic partners in which both the platform owner and the complementor are mutually dependent and aligned" (Hein et al. 2020). As a product in a manufacturing context can only be created through the complex collaboration of the individual components, many machines as well as software or service suppliers are closely linked to the platform and therefore have a low autonomy in the platform ecosystem. **Requirement DR-2**: The organizational setting of the ecosystem should be one of rather tight coupling.

### 3.2.3 Control Mechanisms

Control mechanisms regulate the integration and orchestration of actors in the platform ecosystem (Tiwana 2014). Regulation shall incentivize and control the platform entities such that the highest possible value is generated (Talmar et al. 2018). De Reuver and Bouwman (2012) structure platform control into three types: authority-based, contract-based, and trust-based control. As the manufacturing resources in a CM setting originate from different companies offering complementary but also competing products and services, an authority-based approach is inappropriate. A purely trust-based mechanism built on confidence is too risky. A structure that uses negotiated agreements, such as contract-based control (De Reuver and Bouwman 2012), is the form to be aspired to. Contracts must include mechanisms to motivate and control participants in order to generate collaborative value. Depending on the organizational structure, the agreements must be flexible and adaptive in their conclusion and modification without incurring disproportionate transaction costs (Parker and Van Alstyne 2018). **Requirement CM-1**: The regulation of actors as part of the governance concept should rely on flexible contracts, which must not incur disproportionate and severe transaction costs.

Gatekeeping is another control mechanism, regulating who participates under which conditions as well as which products and activities are granted, promoted, or punished (Tiwana 2014). It also includes IT use, which acts as a regulatory instrument but also in a self-regulating manner (Boudreau 2010). As the integration of a new machine or activity into the complex context of production cannot be assessed a priori, due to the heterogeneity of machines and unpredictable qualitative effects on the product, gatekeeping should be restrictive and subject to clear constraints. However, strict restrictions inhibit the ecosystem's ability to innovate, with a negative impact on value creation (Isckia et al. 2020). Hence, it is important to balance the ecosystem's effectiveness and innovativeness. **Requirement CM-2**: Gatekeeping as part of the governance concept should balance restrictiveness and openness for innovation.

Table 1 shows the discussed requirements for the CM ecosystem governance concept. These requirements are rather abstract and derived from the starting point that value distribution within the ecosystem should be fair.

| | **Requirements** | | | |
|---|---|---|---|---|
| Architecture | **A-1**: The governance concept and its design patterns should fit the architecture of CM. | | | |
| Pricing Policies | **PP-1**: The pricing mechanism as part of the governance concept should support value-based pricing. | **PP-2**: The value distribution mechanism as part of the governance concept should enable a fair value distribution for all contributors. | **PP-3**: The distribution of value that the customer is willing to pay for should be in relation to the input of all contributors. | **PP-4**: Value should be distributed when the customer pays for the service, so that involved contributors share risk equally to their input ratio. |
| Decision Rights | **DR-1**: The platform owner, as a cloud operator, should be organized in such a way that all contributors of the ecosystem's stable core are allowed to co-decide. | | | **DR-2**: The organizational setting of the ecosystem should be one of rather tight coupling. |
| Control Mechanisms | **CM-1**: The regulation of actors as part of the governance concept should rely on flexible contracts, which must not incur disproportionate and severe transaction costs. | | **CM-2**: Gatekeeping as part of the governance concept should balance restrictiveness and openness for innovation. | |

**Table 1: Requirements for a CM ecosystem governance concept**

# 4 Design Patterns for the CM ecosystem governance

To address the requirements, we argue for design patterns that help to implement the CM ecosystem governance concept. DR-1, DR-2 and CM-2 (see Table 1) are organizational requirements that affect the structural form of the platform owner and by whom the platform owner is represented. Hein et al. (2020) propose three different manifestations of platform ownership: 1) a single owner, 2) a consortium, or 3) a peer-to-peer community. A single owner is excluded on account of requirements DR-1 and PP-3. A pure peer-to-peer community does not fit with tight coupling (DR-2) and rather restrictive gatekeeping (CM-2). Also, knowledge and data protection issues within the production process are arguments against a peer-to-peer solution. Thus, the platform owner should be represented by a consortium that consists of a stable core of "insiders" in the ecosystem. **Design pattern DP-1**: The platform owner will be represented by a consortium of core contributors of the ecosystem (organizational pattern).

Using Baran's view of communication systems as a base (Baran 1964), Mattila and Seppälä (2018) differentiate the structure of decision rights from centralized over decentralized to distributed. We propose a decentralized decision rights structure that fits a consortium organization. The contributors must agree collectively on all major decision-relevant aspects, such as value distribution, offerings, or new members. These rules must be implemented (as far as possible) into a technical system that operates as a boundary resource (Ghazawneh and Henfridsson 2013). **Design pattern DP-2**: The consortium will implement a decentralized decision rights system (organizational pattern).

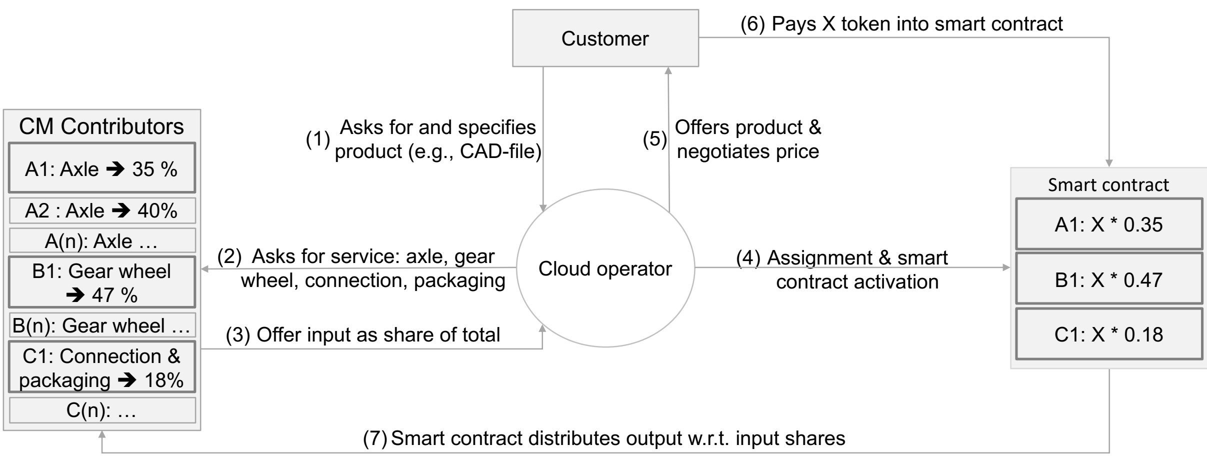


**Figure 2: Exemplification of the fair value distribution concept**

PP-2 – PP-4 are key requirements for the fair value distribution. The contributors of any special output (service or good) negotiate how large the share of the output for each contributor is and set this in contracts. For example: Contributor A1 (axle) claims 35% of the share of the pay, B1 (gear wheel) claims 47%, and C1 (connection and packaging) 18%. The contributors may be unaware of how much the customer is willing to pay at the time of agreement. They get the share they have agreed upon. Selecting contributors is done by the cloud operator. For that purpose, the cloud operator leverages an auction-based mechanism to find a contributor for each task that has to be fulfilled and selects the one who is willing to accept the smallest share (Figure 2). **Design pattern DP-3**: Value distribution will focus on the value of input expressed as a share of a total. This input share will serve as the output share of the price the customer is willing to pay. The cloud operator ensures that the sum of shares does not exceed 100% and uses an auction mechanism to determine the smallest sum of shares (organizational pattern).

A sales function specialized to coordinate the customer wishes and to achieve a good price from the customer supports PP-1 as the price mechanism is not cost-oriented but the customer has a strong position in price discovery. The cloud coordinator is responsible for implementing this sales function.

To meet requirement CM-1 and to be able to implement flexible contracts between the contributors, it is helpful to automate the negotiated contracts smartly. Therefore, the concept of smart contracts is promising (Szabo 1997). Smart contracts are legal agreements that make use of information technology to ensure their own enforceability and autonomously initiate actions that were previously contractually agreed upon (Cong and He 2019): for example, the release of an amount of money after a receipt of goods. In platform ecosystems, contract-based governance can be established through smart contracts. This can include different types of commitments, such as financial assets with a functional value, internal management, monitoring, allocation of outcomes, intellectual property, external relations, or conflict resolution. Value capture mechanisms can implement split revenue schemes in an equilateral manner and without monopolistic pricing structures by using smart contracts (Mattila and Seppälä 2018). **Design pattern DP-4**: To implement the contract and consortium-based governance model and to enable split revenue schemes, smart contracts will be used as the technical base of contractual governance (technical pattern).

DP-1 – DP-3 are design patterns that address the key dimensions of our CM ecosystem governance concept. The organizational design pattern DP-1 prevents the cloud operator from assuming a disproportionate position of power and is important for the fair value distribution as the platform owner has no incentive to optimize for its own profit (cf. Boudreau and Hagiu 2008). The organizational design pattern DP-2 enables a fair value distribution for the contributors and follows equity theory (e.g., Adams 1963). The larger a contributor's input proportion is, the higher is its entrepreneurial risk. Hence, its share of the output should also be proportionally higher. The scheme is fair according to equity theory and risk. The contributors are incentivized to perform well, as every contributor directly profits from customers being satisfied with the output.

To support DP-2 technically, we propose the use of tokens. A token is a reference of any intrinsic or perceived value (Federal Ministry of Finance (ed.) 2019). It represents a generic and measurable unit of value closely connected to the rules of the network issuing it (Pazaitis et al. 2017). Tokens can perform governance functions in platform-based systems (such as the control functions of monetizing, resourcing, and securing) but also management functions such as attracting, sharing, and coordinating (Lipusch et al. 2019). This makes them suitable for our application context, both from a technical and an organizational perspective. The tokens serve as a means of payment within the CM ecosystem. Smart contracts administrate and distribute the tokens (accordant to DP-3). **Design pattern DP-5**: To share value according to the split revenue scheme, tokens will be implemented as a value reference managed by smart contracts (technical pattern).

Pattern DP-3 allows the platform to be organizationally flexible and regulated by contracts. DP-4 allows for distributing the shares in a technically sound manner, administered by smart contracts. Both patterns describe technical approaches. Thus, smart contracts and tokens have to be embedded in a technology layer able to supervise these contracts and transactions. Distributed Ledger Technology (DLT) is able to supervise and validate transactions and to store them tamper-proof (Beck et al. 2018). DLT is able to build a ledger storing transactions with the following characteristics (cf. Heumüller and Richter 2018):

- The ledger is replicated on different nodes and exists as long as at least one node is active.
- The acceptance of transactions (validity) is confirmed by a decentralized (e.g., democratic) process between the nodes.
- The sequence of transactions is unchangeable.
- Transactions are protected against subsequent manipulations by cryptographic techniques.

To realize DLT, there are a multitude of different concepts (e.g., blockchains, or directed acyclic graphs) implemented by different designs (e.g., Bitcoin, Ethereum, IOTA; cf. Kannengießer et al. 2019). Some designs are able to handle smart contracts, such as Ethereum[4] or Hyperledger.[5] With the support of DLT, smart contracts are supervised technically and provide greater contractual security than conventional contracts do. At the same time, smart contracts reduce transaction costs (Tönnissen and Teuteberg 2018). DLT has also gained attention for governing multi-sided platforms (Lipusch et al. 2019; Mattila and Seppälä 2018). In these concepts, tokens play a central role for payment (Lipusch et al. 2019; Pazaitis et al. 2017). DLT is also proposed for CM management purposes (e.g., Angrish et al. 2018). **Design pattern DP-6**: A DLT infrastructure capable of handling smart contracts will be implemented to support the concept of flexible contracts and consortium-based platform management (technical pattern).

Table 2 summarizes the proposed design patterns which will be implemented to support our CM ecosystem governance concept that enables fair value distribution.

| Require-ments | Design Pattern |
|---|---|
| DR-1, DR-2, CM-2 | DP-1: The platform owner will be represented by a consortium of core contributors of the ecosystem (organizational pattern). |
| DR-1, DR-2, CM-2 | DP-2: The consortium will implement a decentralized decision rights system (organizational pattern). |
| PP-2 – PP-4 | DP-3: Value distribution will focus on the value of input expressed as a share of a total. This input share will serve as the output share of the price the customer is willing to pay. The cloud operator ensures that the sum of shares does not exceed 100% and uses an auction mechanism to determine the smallest sum of shares (organizational pattern). |
| CM-1 | DP-4: To implement the contract and consortium-based governance model and to enable split revenue schemes, smart contracts will be used as the technical base of contractual governance (technical pattern). |
| A1, DP-2 – DP-4 | DP-5: To share value according to the split revenue scheme, tokens will be implemented as a value reference managed by smart contracts (technical pattern). |
| DP-3, DP-4 | DP-6: A DLT infrastructure capable of handling smart contracts will be implemented to support the concept of flexible contracts and consortium-based platform management (technical pattern). |

**Table 2: The design patterns supporting our CM ecosystem governance concept for fair value distribution**

Figure 3 depicts the integration of the CM ecosystem governance concept into the layer architecture of CM, using a schematic example. A customer asks the sales function for a service and suggests a price (application layer). This service has to be described semantically according to the CM standard. The sales function prepares a smart contract with the token amount proposed by the customer.[6] The customer activates the smart contract by transferring the tokens. The coordinator distributes the customer request in the ecosystem and asks for offerings. The contributors (machine A, machine B, and the sales function) place their offerings (45%, 40%, and 10%) to the coordinator (middleware layer). The coordinator solves two problems for the customer by analyzing: 1) if the required resources are available on time (machines A and B can offer the service respectively); and 2) if the resource providers all together ask for an output share less than 100% (95% in the example, i.e., valid). Thus, the coordinator refines the smart contract, which encapsulates a distribution scheme with machine A getting 45%, machine B getting 40%, the sales function getting 10%, and the coordinator the remainder (5%). With the service delivery, the smart contract is fulfilled. The customer gets the service and the contributors the respective tokens. All ecosystem partners can benefit if ecosystem services become popular and valuable, as the reference value of the tokens will increase.

[4] https://ethereum.org/en/

[5] https://www.hyperledger.org

[6] The customer can purchase tokens after an Initial Coin Offering via a token exchange (e.g., Lipusch et al. 2019; Richter and Heumüller 2020).

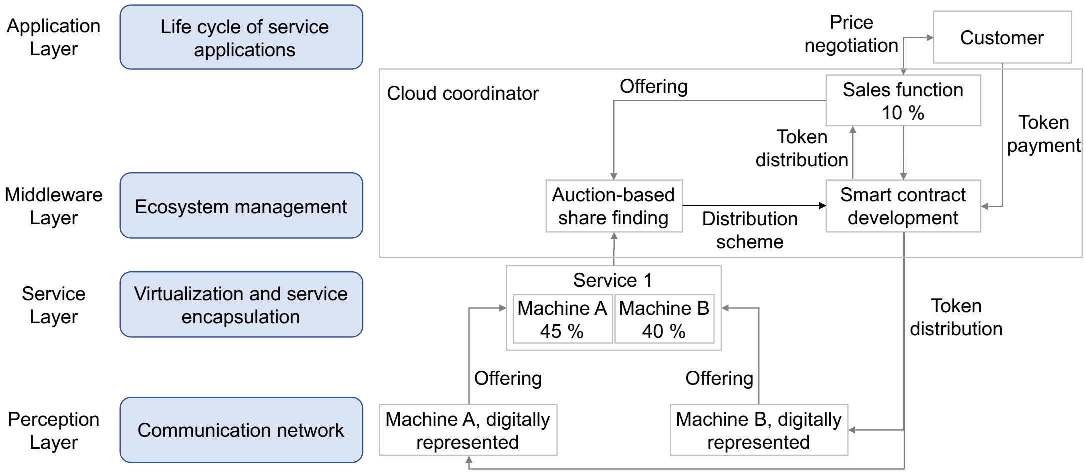


**Figure 3: CM layer architecture integrating our fair value distribution concept**

## 5 Contribution and Limitations

This contribution identifies design patterns to support the implementation of a CM ecosystem governance concept that focuses on fair value distribution and avoids power asymmetries within the ecosystem. To find these design patterns we analyzed requirements for the CM ecosystem governance concept according to the literature. All requirements can be implemented by different designs. We analyzed which design options fit best for our purposes. Thus, we propose three organizational and three technical design patterns for solving our problem. On the basis of the identified requirements, it becomes apparent that neither the platform operator nor any other participant may hold a monopolistic position. Instead, it must be possible to map decisions via collaborative distributed mechanisms. The proposed design patterns offer a template to these challenges and can help to implement an ecosystem that is perceived as fair by the actors involved in the value chain by leveraging innovative technologies and frameworks such as blockchains, smart contracts, or tokens.

We suggest the platform owner to be represented by a consortium of core contributors of the ecosystem and to implement a decentralized decision rights system in that consortium. The value distribution within the ecosystem should be according to the input share a contributor offers and take place for all contributors when the customer pays the entire product. Smart contracts that handle tokens to realize the split revenue schemes within the ecosystem are suggested as technical design patterns. These smart contracts and the tokens should be implemented on the basis of a DLT infrastructure.

These design patterns will serve as the focal theory (Davison et al. 2012) for the action-taking phase in our AR project with TRUMPF and FESTO. With these two practical partners we will implement the CM ecosystem governance concept and research the complex interactions within the ecosystem. The implementation will focus on small and medium-sized enterprises and foster the innovative power of these businesses.

As with the majority of studies, the design of the current study is subject to limitations. Firstly, the concept is not implemented yet. The proposed novel technologies such as DLT or smart contracts have not yet been fully explored and are therefore not yet completely understood. Secondly, when the concept is implemented, it is vague as to whether and how potential contributors will adopt it. To understand the complex interdependence of technology and organizational behavior a priori is impossible, calling for a cyclical process of designing and implementation in an organizational environment (Sein et al. 2011). However, this process starts in the action-taking phase based on this concept. Thirdly, the proposed ecosystem calls for standardized products that are easy to specify and easy to supervise in matters of quality. At best, the network forming ecosystem can be understood as a possibility for innovators to produce small series of new products without inducing fixed costs into their calculations. Lastly, the concept of a fair value distribution is not yet broadly discussed with practitioners, who ultimately are the potential implementors. Taking their comments and critique seriously is crucial for developing the theory of the concept further.

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