VALUE CREATION DESIGN: MODELING OF VALUE NETWORKS

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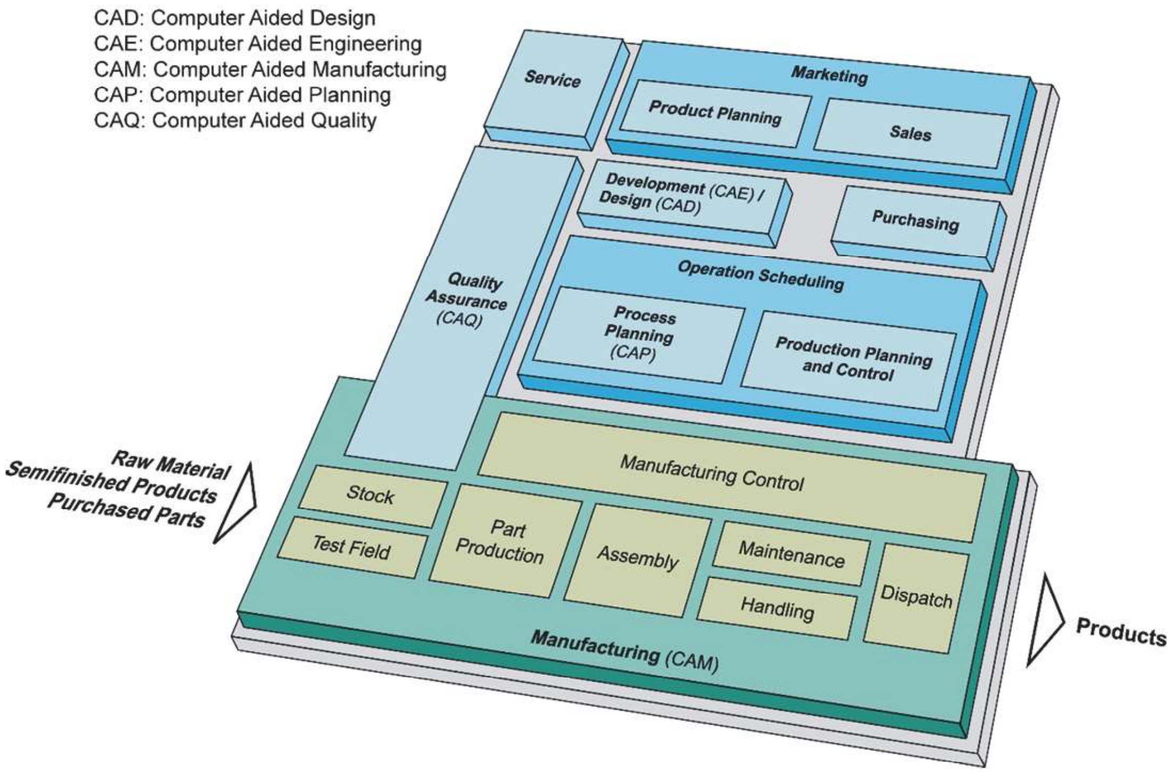
As digitalization revolutionize products, production systems and entire value creation, the implications for manufacturer's business opportunities are huge. Filling out well-known frameworks will not suffice anymore for successful business. To take advantage of digitalization-based opportunities, organizations need to rethink their mindset about value creation. One of the key challenges is a thorough planning of the value network to achieve a well-structured shift from current, outdated to future value creation. Organizations simplify planning and analysis of business models to improve or reinvent them. This paper presents a modeling language for value networks to support planning and complexity reduction. Modeling the rationale of how an organization creates, delivers and captures value and the interrelations of how organizations operate in value networks is a powerful technique for incremental concretization and improvement of new business models and customer-seeking products and services.

INFORMATION TECHNOLOGY TRANSFORM VALUE CREATION

Information technology permeates products and services, thereby making them smart. Based on new technologies innovative products unleash a new era of competition. Once engineering products or products of congeneric industries, e.g. automotive, composed solely of mechanical and electrical parts (Porter et al., 2014), (Schuh et al. 2009). Nowadays, they are complex systems combining hardware, software, control engineering, sensors and microprocessors. Communication and information technology offer exponentially expanding opportunities for new perspectives that cut across and transcend traditional product boundaries. Entirely new industries emerge as old ones crumble during the evolution from national industrial societies to one global information society. The scale and the speed at which innovative products are transforming industry nowadays is unprecedented. They also reshape the nature of organization's value chains. Myriad crowding-outs of incumbent market leaders illustrate the vast consequences. For manufacturer's disruptive technologies and digitalization merge the real and virtual world to the internet of things as a key driver. This trend is often coined by the terms industrial internet and industry 4.0, respectively (Kagermann et al., 2013), (Gausemeier et al. 2014).

According to our experience, manufacturers perform a vast number of activities to engineer products and get them to customers. This generally takes place in functional units (Figure 1) (Gausemeier et al., 2014). A briefly characterization of the functional units is given below.

FIGURE 1
MANUFACTURERS' FUNCTIONAL UNITS



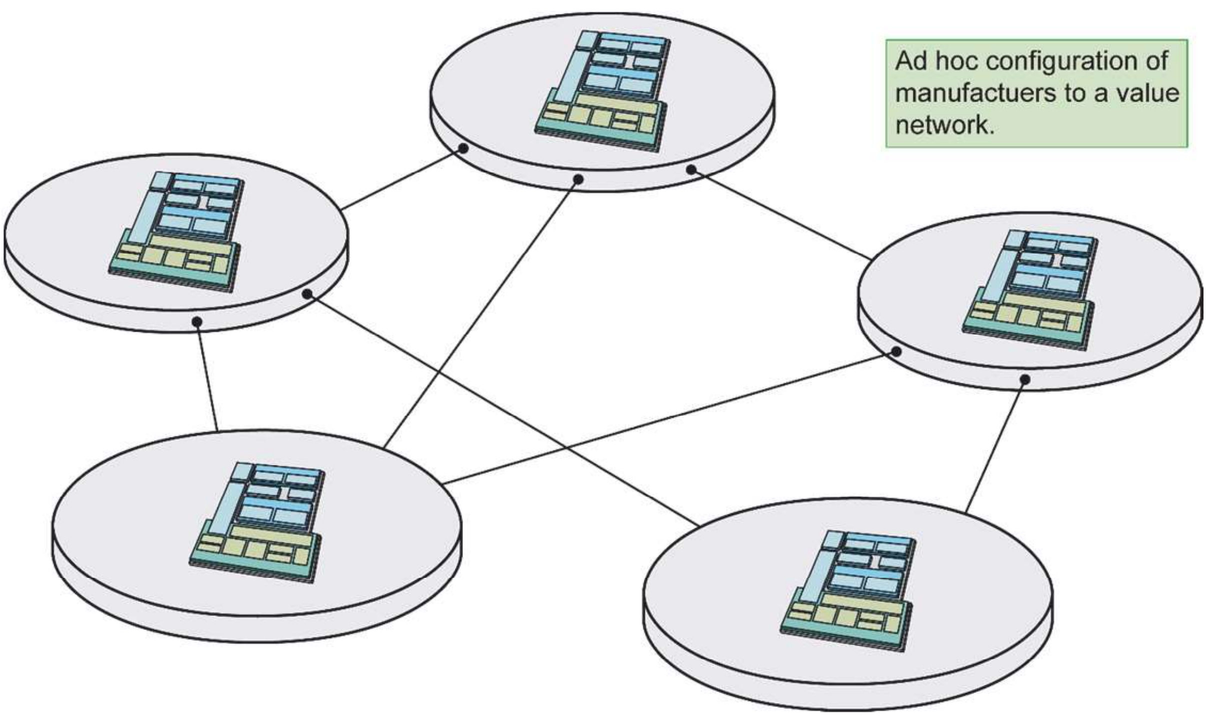
- **Product Planning:** Major task of this unit is planning new products or product features. Essential results are development orders und business plans. A development order comprises a market-oriented product specification (catalog of requirements, functional specification document) and determinations of quantities, production costs, development period and expenses. The business plan shall provide the evidence of an attractive return on investment over product life cycle.
- **Development and Design:** Major tasks are product concretization and function verification. Results are construction documentation such as production drawing, part lists and equivalent digital models.
- **Operation scheduling:** As a superordinate area, it encompasses manufacturing operations planning, scheduling and dispatching.
- **Sales:** Major task is achieving customer orders. Products in need of explanation a pre-sales support supplements the sales. **Marketing** in terms of pricing and distribution policy can be allocated to both sales and product planning.
- **Purchasing:** This unit takes the responsibility for procurement transactions. It supports the timely supply of third party materials and components.
- **Manufacturing:** The functional unit is actual factory operation. Machines assemble the developed products based on the previous units.
- **Service:** The post-sales support includes installation, commissioning, maintenance and spare parts.
- **Quality Assurance:** It is a cross-unit function entailing quality planning and control (Pfeifer 2001).

Until now, manufacturing ends once the product was delivered. The new product capabilities alter almost every functional unit. For example, the final assembly shifts to the customer site: loading, configuring software and personalizing. Core of what revolutionize value creation is data. In consequence, manufacturing exceeds the production and become a continuous process. Often products cannot operate without cloud-based technology. The technology infrastructure must operate and be improved throughout the product life cycle. Thus, manufacturer can provide continual value. The discrete product quality is part of the quality assurance of the complete related system. Technological advancements coupled with products as components of lager systems broaden the value proposition. The well-known value chain introduced by Porter connects the functional units of one manufacturer with each other logically. The manufactured products or distributed services are the input for the company followed in the value network () (Porter 1999), (Gausemeier et al., 2014).

However nowadays, innovations and innovative products are mostly, if not exclusively, created in networks (Propawe, 2015). Vertically integrated and horizontally linked process unlock vast potentials for innovations (Kage et al., 2016). For example, intelligent machines, resources, products, warehouses and conveyer systems configure themselves via the internet to powerful value networks.

While companies in value chains have been rigid coupling to each other, partners in value networks often form weak combinations (Lusch et al., 2009). For example, open innovation constitutes external knowledge to enhance a company's innovation potential and requires a harmonization of processes and collaboration, within a value network (Yassine and Braha, 2003). As the internet of things triggers a new era of competition, complex value networks and innovative business models are required (Chesbrough, 2010), (Porter et al. 2014).

FIGURE 2
HORIZONTALLY LINKED VALUE NETWORK



The last decades are hallmarked by an eminent shift from a seller to a buyer market. Customer have to be acquired and satisfying their demands became an outstanding success factor. Customer orientation requires structured value creation. Proven methods for division of labor established in the era of mass production are not effective any more. Increasing diversity of variants of products, rising product complexity and emerging information technology enforce organizational effort. From these points of view, it comes down to a consistent planning of value creation covering network and process structure as well as related business models. Network structure means the functional arrangement. It is necessary whenever a collective purposive creates value, whereas the process structure organize the actual value creation. Business models pull both aspects together to describe the basic logic a company achieve profit. At this point, basic element for promising value creation is a new culture of collaboration irrespective of traditional organization boundaries. Broadly speaking, value creation is an abstract issue. To deal with it constructively and conscientious, modeling simplifies the complex reality focusing essential aspects for the defined scope. Specifications range from non-formal representation, used to harmonize the fundamental understanding, to detailed formal representations to apply workflow management (Kage et al., 2016), (Gausemeier et al., 2014).

CHALLENGES OF VALUE CREATION DESIGN

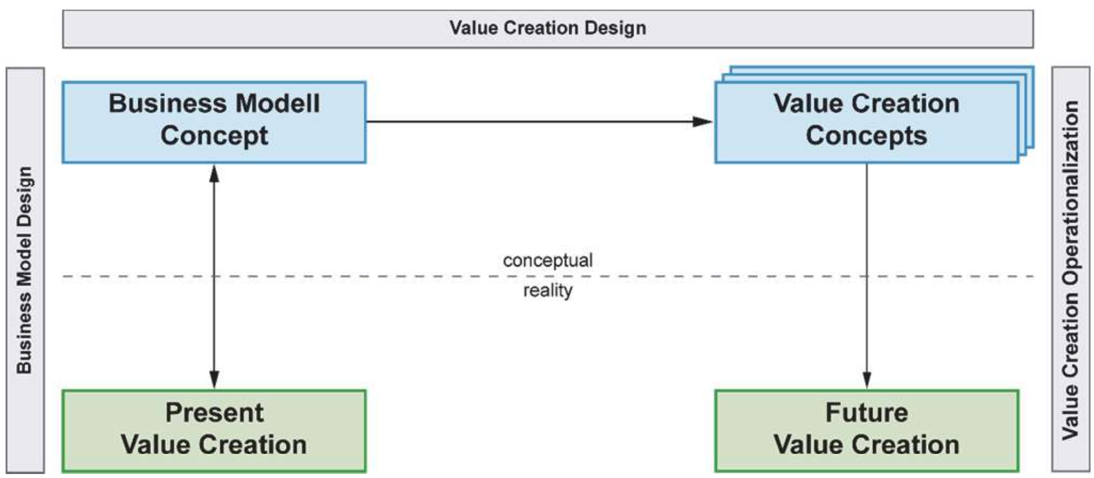
As the internet of things, emerging powerful paradigms naturally require new design and development methods. It poses the question whether established approaches for value chain and business model development must be enlarged fundamentally. In particular, this question concerns the early phases *value proposition design*, *business model development* and *value creation design* (Osterwalder et al., 2014), (Porter, 1999). For these phases, the basic structure (e.g. describing the value map or the value creation model) also applies to products in the context of the internet of things. A close-up shows that established methods for value chain and business model development must essentially be expanded. They emphasize individual aspects or general guidance. For example, business-engineering methods focus internal processes and operations and are less suited for business model implementation into practice (Oesterle, 2006). Yet others recommend the configuration of process model, participant model, transaction model and revenue model to realize a business model (Bach et al., 2010). Previous techniques for factory planning or conceptual design of production systems are not linking value creation and business model development (Hahn et al., 2006).
Developers repeatedly use standardized solutions for their engineering tasks (Gausemeier et al., 2008). This applies to product engineering, business models and value networks as well. For example, the active structure is the core of the principle solution in the mechanical design. It describes the relation of active principles and is basis of building and component structure. Relating to value networks the active structure describes the manufacturer's functional structure and their relation. As an intermediate step in the course of concretization, it links functional units even beyond organizational boarders. Escalating capabilities of connected products not only intensify competition, it shifts from products, to connected products, to product systems comprising consistent related products, to system of systems that raise product systems together. To make matters worse, main challenge for value creation design are innovative technologies altering both products and business models. The general design approach from present to future value creation is depicted in **Error! Reference source not found.**. We consider two levels reality and conceptual linked by overarching tasks: Business Model Design, Value Creation Design, and Value Creation Operationalization. This paper focuses the Value Creation Design although the other two tasks are briefly outlined as well.

Core of the need for action is a business model driven modeling language for value networks. It will bridge the gap between business model concepts, a rough, broadly interpretable specification of the value creation, and their future operationalization. The modeling language for value networks is basis for continuous discussions and cooperation during development. In particular, the contemplated modeling language should fulfill the following requirements:

- **Value creation entities:** All value creation units must be specified, especially both physical and digital elements.
- **Value creation activities:** The language must consider value creation and key activities as well as their specific in- and outputs.

- **Value creation infrastructure:** Required resources for manufacturing or assembly and cloud operating infrastructure should treated in equal measure.
- **Organizational relation:** Every attended unit is related to at least one participating unit. The specific relation type (e.g. material flow, cash flow, data stream) should be taken into account.
- **Intuitive modeling:** A graphical notation combining suitable semiotics, syntax and semantic should facilitate an intuitive use for domain-spanning teams.
- **Conceptual design support:** The modeling language should support the specific characteristics of business model development and its operationalization.
- **Complexity management:** Proven structure principles, e.g. hierarchy and modularization, should be considered to enable selective modeling depth.

FIGURE 3
MAIN CHALLENGE: MODELING LANGUAGE FOR VALUE NETWORKS

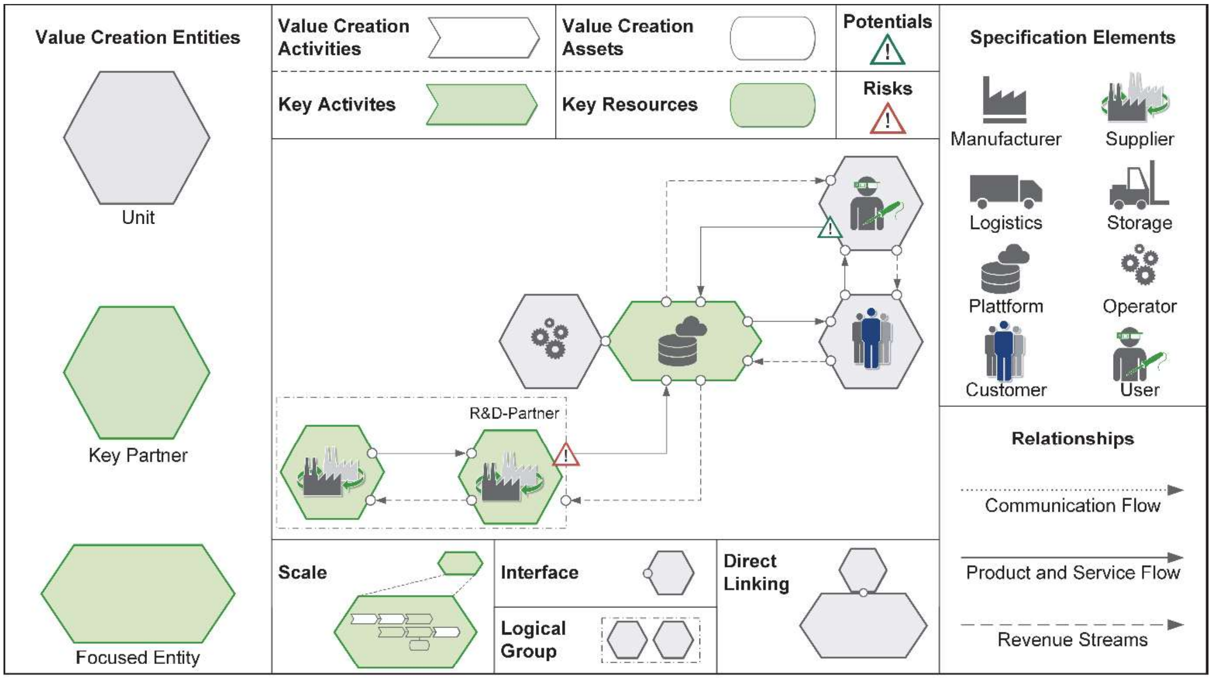


MODELING VALUE NETWORKS

The modeling language arose from a project dealing with business models for Industry 4.0. Their aim was to map activities and relationships of organizations, which participate within the value network, and otherwise be suited for analyzing and planning value creation using concise visualization based on business models. The experience carried out, using the language indicates that modeled value networks are intuitively comprehensible. In restricting of crucial elements, the language applies cross-domain communication and development. The models feature scalable representation of both project- and company-specific content. Furthermore, the modeling language depends on a meta-model enabling computer internal representation of value networks.

The developed modeling language provides a graphic notation representing all relevant issues clearly and relieves modeler as far as possible from textual description (**Error! Reference source not found.**).

FIGURE 4
SUMMARY OF THE ELEMENTS OF THE MODELING LANGUAGE



It maps activity chains, information flow, tangible and intangible products or services as well as revenue streams. The model analysis consists of an evaluation of detected weak spots during modeling and development. **Error! Reference source not found.** gives a summary of the elements the modeling language consists of. The meaning and notation of the elements is described in detail in the following passage.

- **Value creation activity:** An activity is a logical sequence to achieve results or to transform objects. It has a defined trigger and terminal point. Key activities are of particular relevance needed for realization of the considered business model. Using the same notation, activities can be both disassembled to sub-activities and aggregated to a collective activity. This hierarchy enables modeling activities with any degree of detail.
- **Value creation entity:** Entities are units of the value network and interface between a activity and its environment. They represent individuals, group of individuals, institutes, organizations etc. within the value network. Value creation entities are defined stations within the value network executing activities or taking the responsibility for them. They are represented by a hexagon. In particular, key partners execute significant activities or supply certain assets. The focused entity is the core of a value proposition. It represents products and service such as a business-to-business cloud platform.
- **Value creation asset:** Assets support the performance of value creation activities or key activities. All assets must be clearly identified. Typical assets are technical resources such as technical infrastructure, software, milling or turning machines. Key resources are for particular relevance of the business model, without the value proposition could not be realized.
- **Relationships:** They chain up activities, entities and assets. A relationship has a defined transmitter and receiver, that determinate the direction. Relationships are distinguished between communication flow, tangible and intangible product and service flow as well as revenue streams.
- **Specification elements:** Predefined specification elements support user to assign value creation parts in a simple and quick way, e.g. manufacturer or supplier.

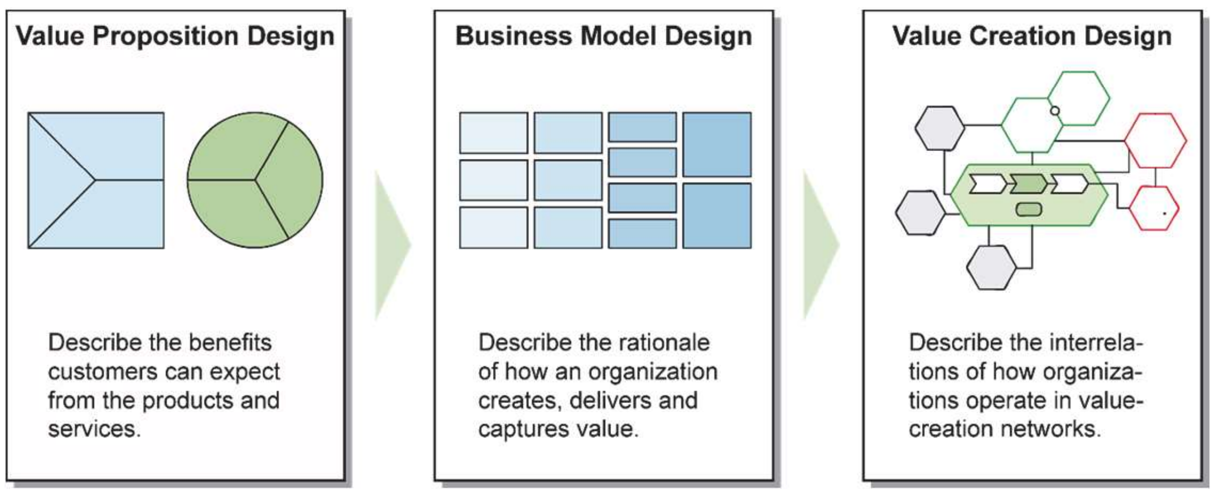
In the following, we show how the modeling language developed in the project "GEMINI – Business Models for Industry 4.0 (Geschäftsmodelle für Industrie 4.0)" supports the value creation design.

BUSINESS MODEL DRIVEN VALUE CREATION DESIGN

As the popularity of business model development increases, many companies visualize their business models to improve or invent them. A succinct visualization can significantly provide a holistic understanding of business activities. Common methods lead to business model visualizations covering different aspects and level of detail. Some focus specific aspects: functional units, collaboration, exchanges of tangible or intangible goods, information or revenue streams, network analysis, but treat relevant transformational processes only as a black box (Weill and Vitale, 2001), (Deelmann and Loos, 2004), (Object Management Group, 2015), (Allee and Schwabe, 2015). Other provide extensive frameworks for holistic business model development neglect the conceptual design of the value creation network (Köster, 2014), (Osterwalder and Pigneur, 2010), (Wirtz, 2010).

For manufacturer's operationalize a business model into operational business requires a thorough planning of the value creation (Rudtsch et al., 2014). The starting point of our approach is the value proposition design toward business model design and value creation design including the developed modeling language (**Error! Reference source not found.**).

FIGURE 5
APPROACH FOR VALUE CREATION DESIGN



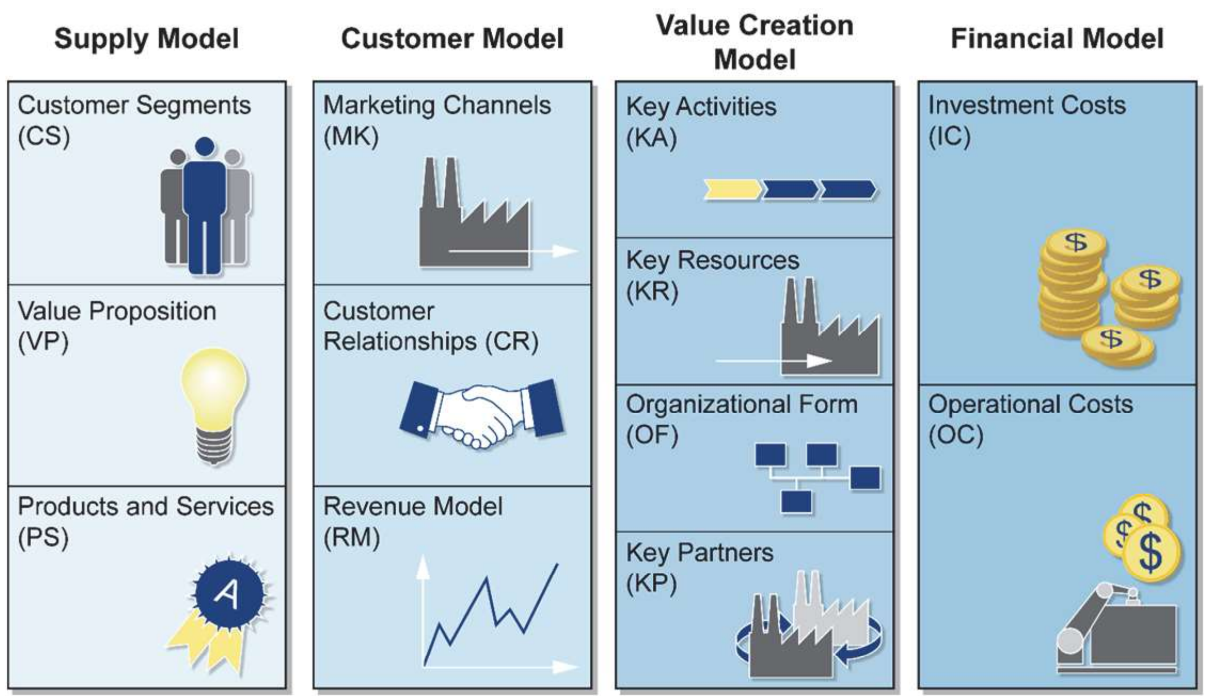
Value Proposition Design

The Value Proposition Canvas introduced by Osterwalder et al. covers two sides: customer profile and value map. The customer profile characterizes your specific customer segments by dissecting and rating their jobs (What are customers dealing with?), pains (What mar their jobs?) and gains (Which improvements and benefits are customers seeking?). The value map describes specific characteristic of the value proposition detailing products and services (Which products and service yield the value proposition?), pain relievers (How products and services mitigate customer pains?) and gain creators (How products and services realize customer benefits?). The fit of both sides customer profile and value map is the core of a winning business idea (Osterwalder and Pigneur, 2010), (Osterwalder et al., 2014). The value proposition canvas already delivers first initial information for later value creation design although only particular preliminary elements.

Business Model Design

Companies that gain less revenue than costs will inevitably vanish independent of tempting value proposition. To prevent it companies transfer their business idea into a success promising business model. Köster suggests a systematics for business model development in the context of product engineering, which provide a procedure from business ideas toward a business model road book. Essential component is a framework, which includes four partial models: supply model, customer model, value creation model and financial model. Every specific partial model encompasses further business model elements (**Error! Reference source not found.**) (Köster, 2014).

FIGURE 6
BUSINESS MODEL FRAMEWORK (KÖSTER, 2014)



As the core of business models, the *supply model* specifies which products and services the company offers for whom and what value the company promises them. It contains the elements customer segments, value proposition as well as products and services.
The *customer model* serves as an interface between the company and customer. The related partial models marketing channels, customer relationships and revenue model describe how the interface is designed.
The *financial model* represents the cost structure that flow from the targeted business. The considered partial models are investment costs and operational costs.

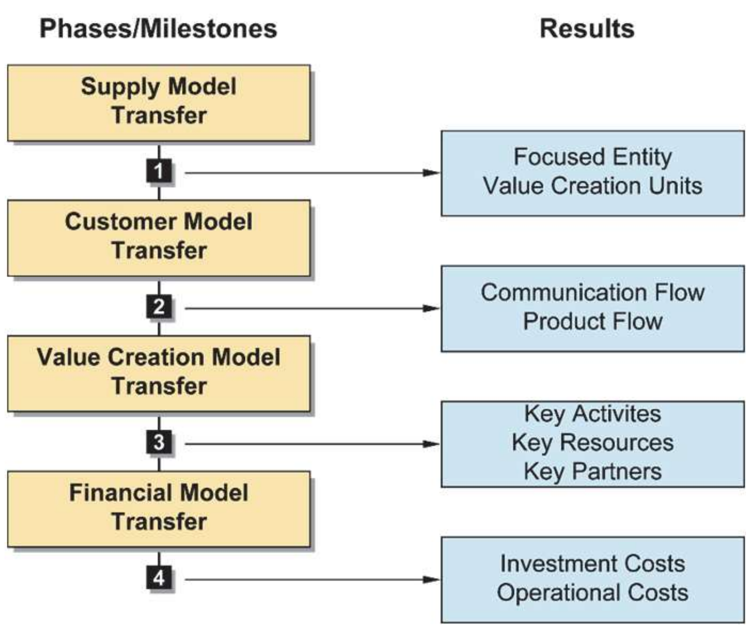
How the company creates its products and services, describes the *value creation model*. It determinates the internal business model perspective. Key activities delineate the central functions needed for realization. Key resources defines the required assets and the organizational form positions the company in the value network. The business model element key partners depicts the complex network of partners and suppliers (Köster, 2014).

The framework clarifies the basic logic of a company's business model. The superior value network the company interacts in still remains unsettled, e.g. the concrete communication or revenue streams and the flow of tangible or intangible goods. The paper at hand primarily aims at a business model driven modeling language, which amplifies the understanding of the superior network for efficient planning, reducing complexity and early evaluations of rewarding potentials, unfavorable-power relationships and risks.

Value Creation Design

For strategic planning, a supply model driven sequencing is promising. Foresight and product discovering initially determinate relevant parameters, followed by transforming the offering into attractive revenue. Based on that, the conceptual design of the products, services and production systems lead to the value creation model. Business planning finally merges the investment and operational costs (Köster, 2014). We subsequently introduce a business model driven modeling language designed to transfer promising business models into their allocated value network. Taking the recommended sequencing up, the modeling language provides each step and follows the four-phase process shown in **Error! Reference source not found.**.

FIGURE 7
PROCEDURE OF MODELING VALUE NETWORK

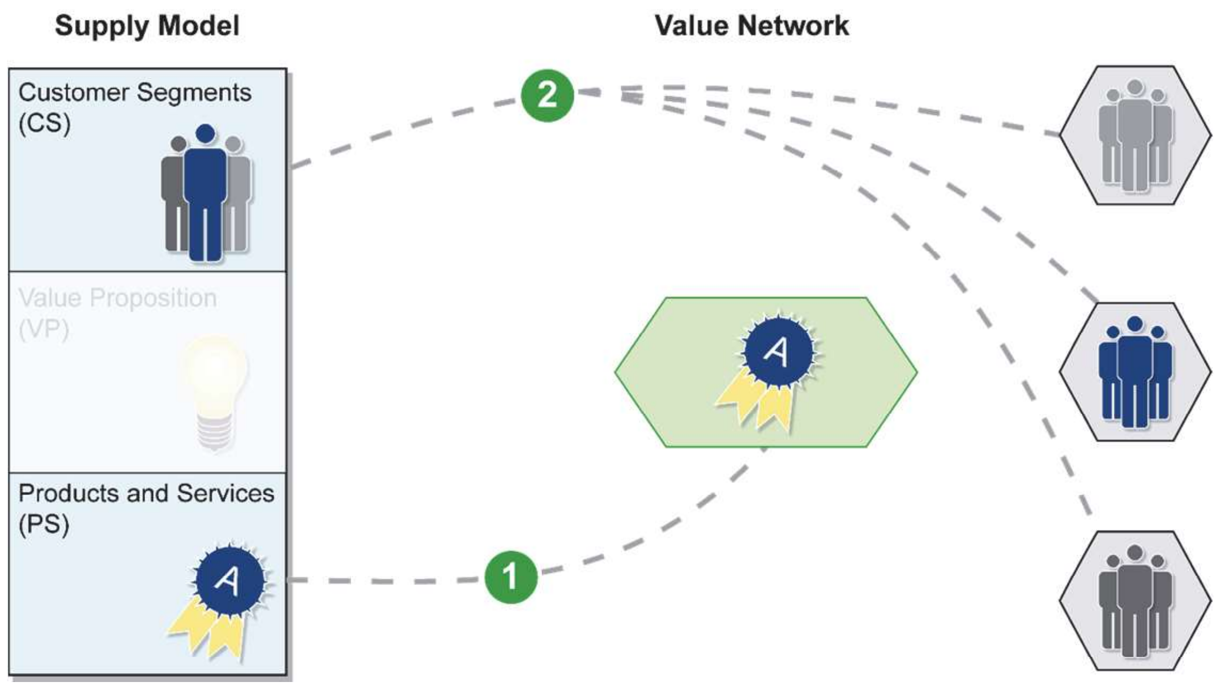


In the following, the modeling language is going to be outlined in detail. To ensure a comprehensive understanding, the phases are hereafter presented using examples from a research project conducted inter alia with manufacturer for additive manufacturing equipment and it-service provider.

Transferring Supply Model

As ideal sequencing advices, the value network modeling starts with the supply model (Köster, 2014). First, the products and services (1) should position. Although, the element contains tangible goods, services or a bundle of products and services as well. We insert the *focused entity* to represent this business model element in the value network. The identified customer segments should orientate toward the value network (2). Therefore, the modeling language provides a general *value creation unit,* which are specified with defined specification elements for segmented customers (**Error! Reference source not found.**).

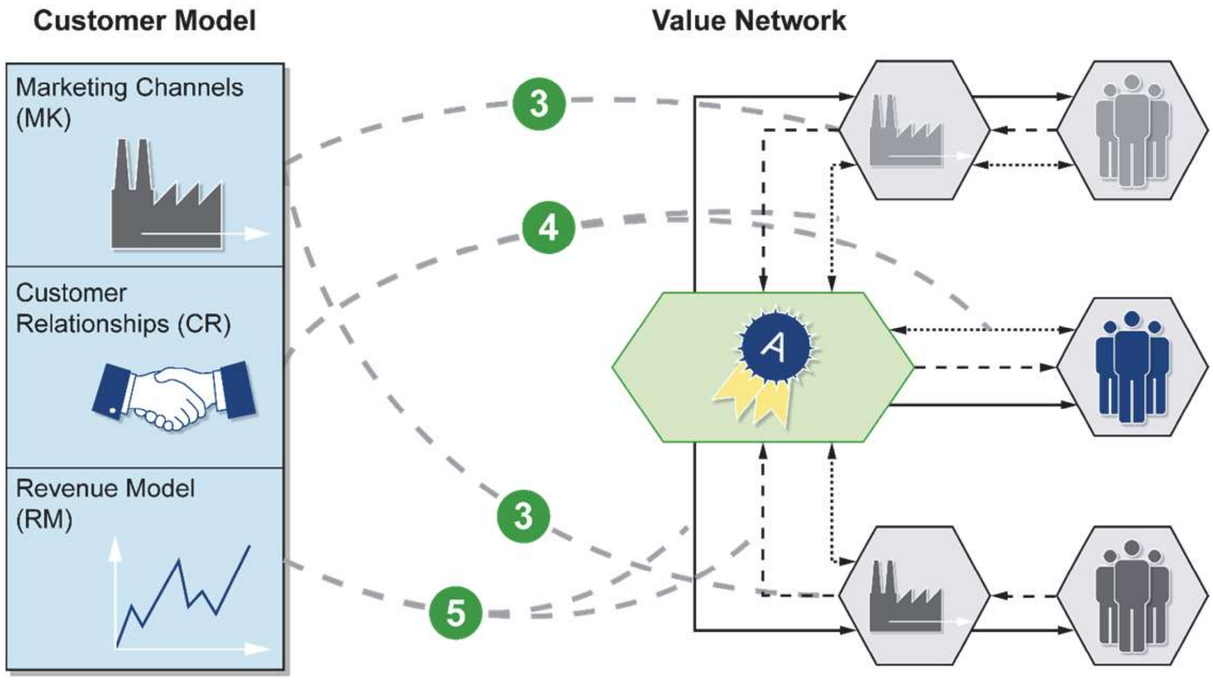
FIGURE 8
TRANSFERRING SUPPLY MODEL INTO VALUE NETWORK



Transferring Customer Model

The customer model, encompassing marketing channels, customer relationships and revenue model, describes the interface between company and customer. Marketing channels defines how to deliver products and services (**Error! Reference source not found.**). Sales agencies operate as complemental *value creation unit* (3) whereas wholesale are in direct contact. Type and intensity a company interacts with their customers can be extracted from the customer relationship. To suffice, the modeling language supplies the relationship type *communication flow* to link customers, sales agencies and the focused entity (4). Potential configuration options are e.g. personal customer service, E-Mail support or priority support (**Error! Reference source not found.**). The revenue model describes how to transfer the value proposition into promising revenue. This suggests two separate flows. One *flow of tangible, intangible goods or services* connecting the focused entity and value creation entities as well as related *revenue streams* outgoing from customers as a second flow type (5). Selling products, offering unlimited service support or a free of charge product training are potential configuration options.

FIGURE 9
TRANSFERRING CUSTOMER MODEL INTO VALUE NETWORK



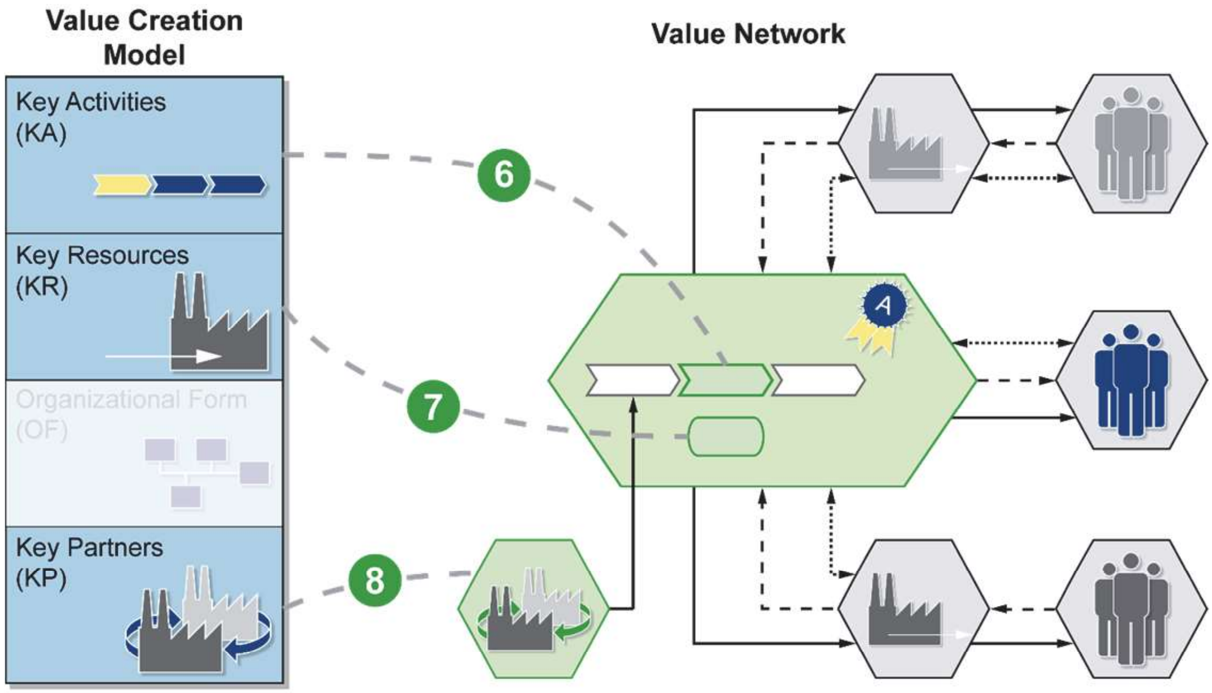
Transferring Value Creation Model

This partial model describes how the company creates its products and services from an internal value network perspective. Key activities and key resources concretize the focused entity, more precisely the functions and the required assets for realization. Therefore, integrate the *key activities* into the focused entity (6). For example, key activity options are research and development, production, cloud operation or logistics. Normally key activities need *assets* (e.g. technical resource, human resource) for operation. Resources can be developed internally and allocated to their related key activity (7) or procured by the market. *Key resources* are of particular relevance to realize the promised value proposition. The latter leads to *key partners*, which build the complex value network. Key partners undertake particular activates (e.g. software development) or supply certain assets (e.g. cloud operation, payment handling) not covered by the company. Besides, key partners can also deliver special pre-products, which are of particular relevance (8) (**Error! Reference source not found.**).

Transferring Financial Model

The Financial Model separates into investment and operational costs representing the resulting business cost structure. Purchased hard- and software or expanding the shop floor determine investment costs, whereas staff costs or cost for cloud operation count among operational costs. Based on the financial model the modeling language supports financial risks and cost potential identification.

FIGURE 10
TRANSFERRING VALUE CREATION MODEL INTO VALUE NETWORK



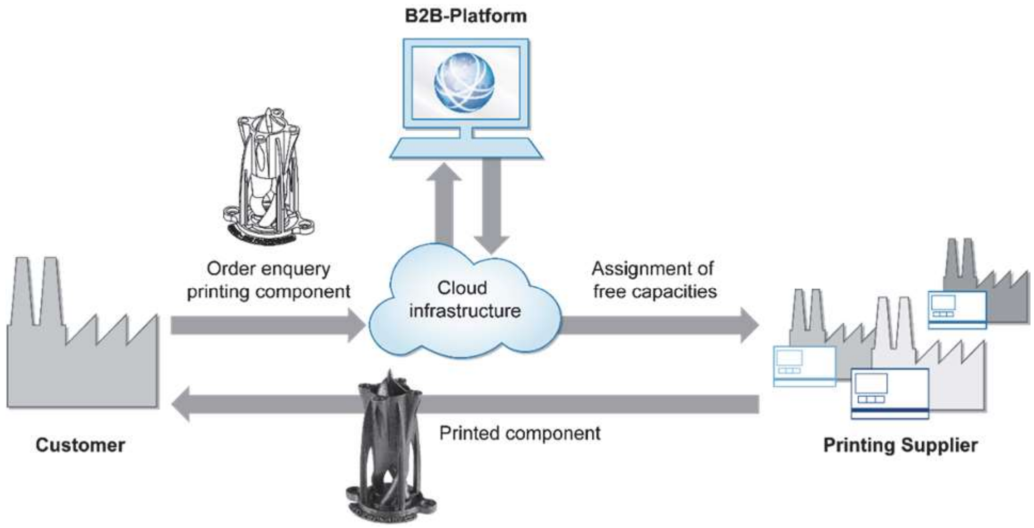
Example: Cloud-based Capacity Platform for Additive Manufacturing

Additive Manufacturing technologies are gaining more and more importance. Many industries benefit from the technological advantages such as the freedom of design (Gausemeier et al., 2011). In comparison to the technological benefit, the usage of the additive manufacturing machines are in need of improvement for printing suppliers to achieve attractive profit. Therefore, a cloud-based capacity platform is part of our research project GEMINI (**Error! Reference source not found.**).

The cloud-based business-to-business capacity platform should enable on-demand printing of individualized components. Therefore, the platform connects customers (e.g. designer or developer) to printing suppliers offering all technologies and almost all materials. Suppliers offer free capacity and customers request printing jobs for their individualized component designs. For example, the platform distributes the printing jobs, handles the payment, and provides customer and supplier rating.

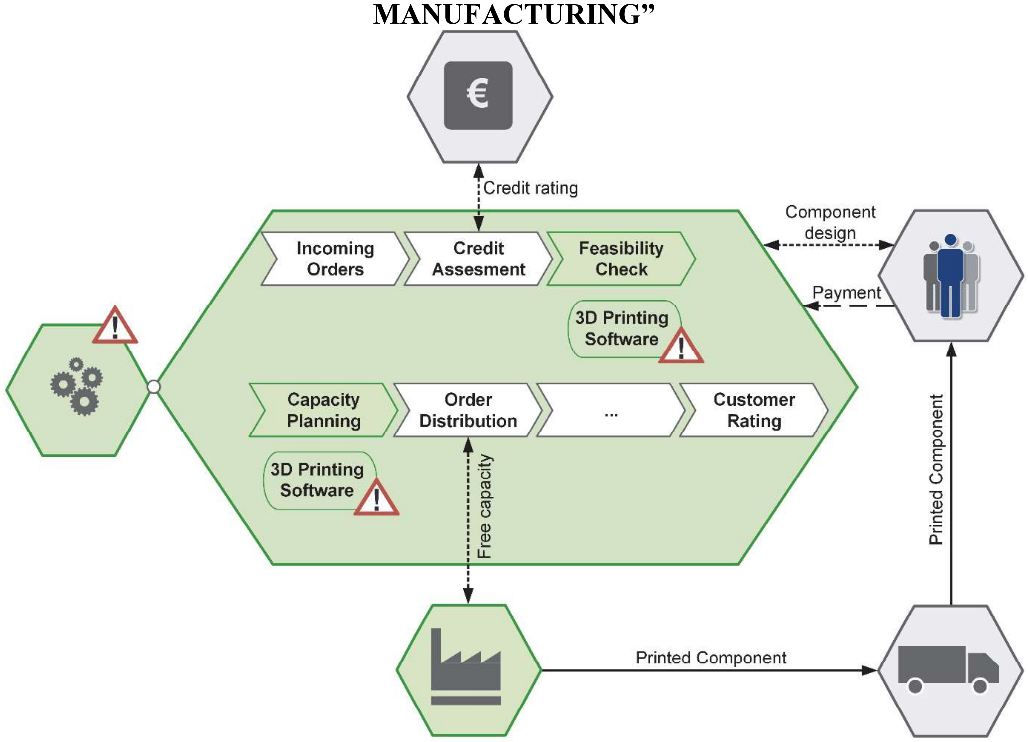
The modeling language now supports the concretion of the idea of a business-to-business platform for additive manufacturing (**Error! Reference source not found.**). Required value creation units and activities can developed gradually. The platform fulfills several activities from incoming orders, credit assessment to customer rating. A third party finance service provider carries out the credit assessment. The platform itself operates two key activities: Feasibility check and capacity planning. The feasibility check proofs the designed component and ensures the printability for selected printing technologies. The capacity planning distributes the print jobs and organizes the assembly of the bounding box. As a key resource, 3D-Printing software supports the two key activities. The platform contains three major threats. On the one hand operating the platform falls normally outside of the competencies of a machine manufacturer. On the other hand, such a required 3D-printing software does not yet exist.

FIGURE 11
BUSINESS-TO-BUSINESS PLATFORM FOR ADDITIVE MANUFACTURING



Our experience has shown, that the modeling language facilitates a holistic understanding of the value network and inspires new ideas (e.g. print certification). Furthermore, it entails unfavorable reliance on single source supplier (e.g. it-service provider for cloud infrastructure).

FIGURE 12
SIMPLIFIED VALUE NETWORK "CAPACITY PLATFORM FOR ADDITIVE MANUFACTURING"



SUMMARY AND CONCLUSION

The revolution of information technology causes a fundamental change in the nature of organizations value chains. The scale and the speed new innovative business models break old ones is unprecedented. This confronts companies with several threats, but also creates attractive opportunities for innovation in business models or value creation. A smooth shift from current, outdated, to innovative business models requires a thorough planning and design of the value creation.

In this paper, we introduced a modeling language for value networks. It enables a systematic planning and operationalizing of value networks based on business models. We achieved several outcomes: (1) A business model driven modeling language is a promising approach to describe communication flow, flows of tangible and intangible goods and revenue streams as well. (2) Modeling value networks inspires new products and services and sensitize to potential risks. (3) Envision key activities, key resources and key partners at an early stage of the value proposition design expedites the market launch. The business model driven modeling language reduces the complexity of value networks and enables an early evaluation of unfavorable power relationships and risks.

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