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Leveraging Digital Twin Based on Artificial Intelligence as a Service in Digital Business Ecosystem

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Abstract. The process of creating value includes the creation of new offerings. Such a procedure needs to be conceptually designed and practically carried out. Here, the emphasis is on how to add value for the client. A suitably established business model is the key aspect. It explains how the development of the product or service is dependent on one another. The many product or service value dimensions are investigated as the business planning's component parts for that reason. The idea of the digital twin offers customers several advantages. A digital twin that provides 3D and spatial information is useful, particularly for stakeholders in plant industries that deal with complex assets. To shape a suitable business model according to the new offering, the approach of the business canvas has been exploited. In this paper, a transdisciplinary conceptual approach to creating a new service offering in a digital business ecosystem is presented.

Keywords. Digital Twin, Artificial Intelligence, Value Creation Process, Digital Business Ecosystem, Business Canvas, Transdisciplinary Engineering.

Introduction

Digital twin counts as the most modern approach for accomplishing complex tasks in the industry. It creates added value for both the customer and the provider. A value creation process includes the creation of new goods and services. It guarantees that client needs or requirements are taken into account and fulfilled in new offerings where the value is perceived as advantageous for the customers. Consequently, new solutions must address and resolve issues, complement existing processes by making them more efficient, or provide the customer and its business case additional benefits [1]. This underlines the transdisciplinary character of a value-creation process based on a technical solution [2].

A thorough understanding of the market, the available cases, and the own solution is a prerequisite. Understanding the advantages of the own solution, how it differs from competing goods or services, and how it meets consumer needs is made easier by value development procedures. In essence, they evaluate the necessity of solutions and their legitimacy before helping one stand out in the market. Although such analysis also provides justifications for better marketing and persuading consumers to purchase a product, value-creation processes are not intended to serve these purposes [3].

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There are several ways to use the value creation process, including boundary spanning, experimentation, usable tools, and recommendations. These techniques encourage the contemplation of business propositions, goods, or services from many angles [4]. This can lead to a profound grasp of both the own solution and the customer's expectations. The target groups might also be identified and the market investigated [5]. In this regard, different shapes are required for products and/or services depending on whether they are created for end customers or business users and the market (B2B or B2C), respectively [6].

With the emergence of the digital twin, the value is usually generated by creating a new software artifact that provides new functionalities that provide quantifiable benefits (e.g., cost savings). In the process industry, the process of the generation of digital twins discovers many characteristics that indicate a one-time or rare application. For this reason, it looks worth investigating the commercialization of a digital twin as a service to be ordered on demand. Technical solutions were presented in past TE conferences on how to generate a digital twin of an existing plant [7][8]. The kernel of this approach is the automated reconstruction of a plant model by methods of artificial intelligence (AI) based on a 3D scan and following object recognition (Fig. 1). How to operationalize this technical solution as a commercial service is the remaing question.

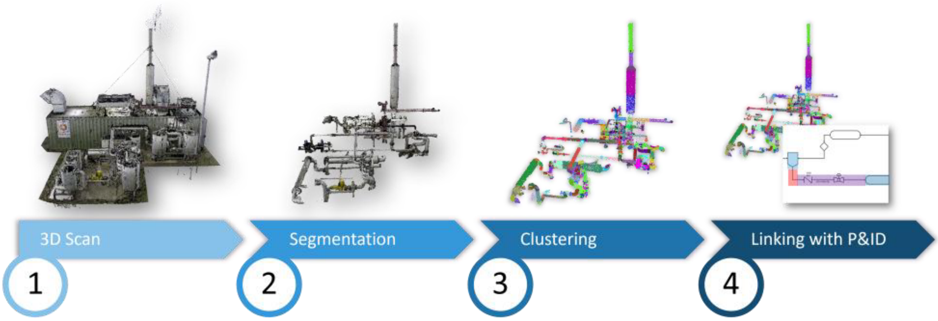

Figure 1. Generation of the digital twin of a process plant [8].

The remainder of this paper is structured as follows: in Section 1 the challenge is briefly introduced. Offering analysis is shown in Section 2. The conceptual definition of a new business model is discussed in Section 3. Subsequently, value creation and business planning are explored in Section 4. Section 5 figures out the customers' view of the digital twin. Before an operation, customers' demand for a digital twin is discussed in Section 6. The paper ends with conclusions and an outlook.

1. Challenge

Sustainable business models pose a key point of a successful service offering. They are built on a triple-bottom-line approach and take into account the interests of many different stakeholders, including the environment and society. Four distinct types of sustainable business models might be identified by a thorough comparison. These business models are deemed sustainable because, when compared to conventional business models, they either (1) suggest efficiency improvements, (2) are founded on novel approaches to making the business sustainable, (3) have a stronger orientation towards society and/or the environment, or (4) are "born sustainable" [4].

A flexible digital twin offering as a service fits the first two types of sustainable business models. However, the main challenge remains to offer an appropriate digital twin to each customer. To achieve this objective, a transdisciplinary method to leverage a digital twin as a service in a digital business ecosystem [9] will be elaborated here (Fig. 2). It discovers how to come from the market analysis to a fine-tailored service that fulfills the demand of almost every customer from the process industry. This multitude of requirements and regulatory constraints can be met by an offering analysis that yields a sustainable business model. Both comprehend the input for value creation and business planning. Based on this, both the customer's views and the customer's views of a digital twin can be derived which is the fundament for dedicated use cases. This approach is transdisciplinary because it combines a technical solution with a commercial service under sustainability constraints.

Figure 2. Conceptual method to leverage a digital twin.

2. Offerings analysis

To evaluate the current market offerings to comprehend them from the viewpoint of the customers The buyer utility map methodology can be used. To depict the customer's experiences at different stages, a matrix is divided into two axes: the horizontal (purchase, delivery, use, supplements, maintenance, and disposal) and the vertical. (customer productivity, simplicity, convenience, risk, fun and image, environmental friendliness) [10] (Fig. 3).

The cells where other market participants already offer solutions are shown by grey boxes. Here, it is not clear whether this solution has advantages or disadvantages. In contrast, the blue boxes identify cells that a recently created solution addresses as blue ocean opportunities. The method of buyer´s utility mapping has been applied for the actual use case of generating a 3D representation of an existing plant.

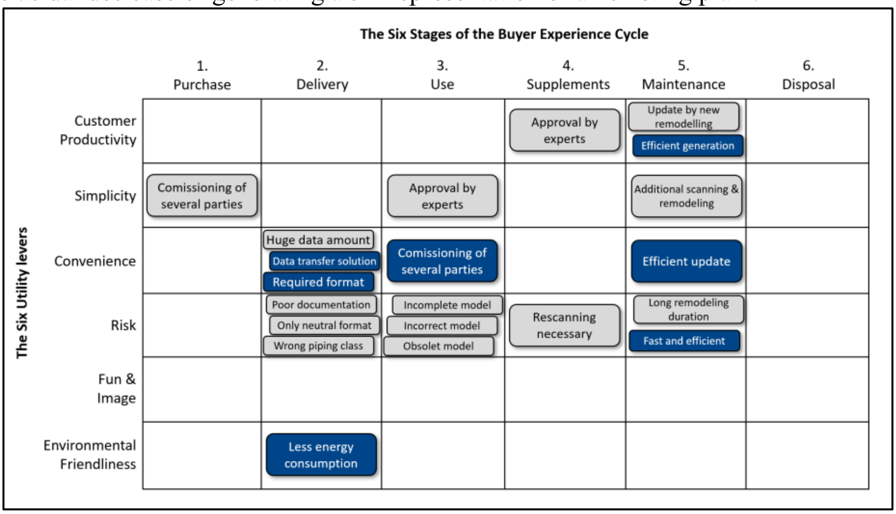

Figure 3. The buyer utility map, derived from [10].

Process plants have lifetimes of several decades. This only can be achieved, when efficiency or productivity respectively is kept to a reasonable level. To achieve this goal plants are modernized at some points in time. Parts or units of a plant are replaced by new ones. To ensure that new a kept parts fit seamlessly, the as-is state of a plant needs to be digitized into CAD models as a reliable planning basis. Nowadays, the as-is state is captured by 3D scanners and digitized into point clouds in a first step. Afterwards, design offices carry out manual remodeling of CAD models within these point clouds.

Firstly, in this offering analysis the current service offered (grey Post-its in Fig. 3) are recorded and depicted. Nowadays, remodeling must be done only manually and is often carried out in countries with a lower salary level than in Europe. A lot of staff lacks the necessary education, which lowers quality. As a result, the customer must double-check the models with the assistance of his subject-matter experts.

The blue Post-its are associated with the service of a highly-automated generation of a digital twin, whereas the grey Post-its symbolize the features of offerings currently on the market. Conversely, some of the traits overlap with one another. All findings are evaluated by experts from the several involved domains. Since the new service requires point clouds as input, these require laser scans beforehand, which need to be carried out by additional companies. The accompanying solution enables customers to transfer data of unlimited size, encrypted and worldwide. A physical sending is not necessary.

Another advantage in terms of delivery is the availability of the desired format. While other offerings prefer the delivery in neutral formats or only limited to a few native formats, the envisaged solution gains from CAD conversion expertise. Hence, delivery in the desired format is made possible (native or neutral). Although the model must be completed and checked twice by the customer, the majority of the work is done automatically and given in the desired format. Inconsistencies need to be fixed if they are found. In some cases, engineers can conduct this with ease. In other cases, it is not possible to identify the precise components using the point cloud alone. That requires further scanning of the plant or at least of the areas of interest. For the new offering as well as the conventional ones, it can be necessary.

Essential to the success of digital twins is maintainability . Existing service offerings are expensive and time-consuming because they rely on manual work. The new offering of automated generation of a 3D digital twin is an efficient and economical way of generating a digital twin with spatial information (CAD models). A laser scan can effectively and accurately capture changes. Based on these characteristics, the new service enables consumers to maintain their plants conveniently, faster, and less expensive in this way.

3. Conceptual definition of a new business model

The initial phase involved identifying the present offerings and discovering the potential blue oceans. to elaborate an appropriate offering and business model, respectively the business canvas approach or a similar method can be used. Nine core components are represented graphically on a business canvas (Table 1) [11]. This provides input for value creation and business planning that is evaluated by an expert team from the several involved domains.

Table 1. Areas of the business canvas, derived from [11].

Dimension	Benefits
Value proposition	Here, the offering to the customer is described. It is important to be clear about the benefits for the customer and which advantages are provided. It must be clear why the customer is willing to go for this specific offer.
Customer segments	The different target groups or potential customers are listed here. This area reflects to whom the offering is shaped and which customers are addressed by the offering.
Channels	When the target group and the offering are defined, the channel to the customer or the access to the offering respectively needs to be defined. This area describes where customers get access to information, marketing channels, and how to place an order.
Customer relationship	After the first contact, the relationship with the customers needs to be maintained. According to the offering, different relations can be established, from self-service to personal contact.
Revenue Streams	Depending on the offering, various order models might make sense. For only a few buyers, a one-time sales model is suitable. If the customer will order regularly, recurring subscription models are conceivable. A license model can be suitable.
Key partnerships	In some cases, collaboration with other companies or partners is necessary or at least beneficial. This can range from suppliers of specific materials to development partners that are needed to implement a solution.
Key resources	Besides strategic partnerships also the resources needed must be considered. Here, an overview of potential investments or costs, key roles in terms of persons, patents, trademarks, or infrastructure can be critical for the success of a solution.
Key activities	The most relevant or crucial activities should be listed in this area of the business canvas. Here, the range can also vary from optimization and processing of the offering to customer relations and gaining new customers.
Cost structure	Each offer also leads to costs/expenses that arise to be able to provide the offer. This starts with costs for personnel involved, infrastructure costs, licenses, materials, etc.

4. Value creation and business planning

To define a business model based on an offering the business canvas methodology can be used. This method has been used to describe the product and lay out the financial structure of a new service that offers the automatic generation of a digital twin. The canvas has been developed at a workshop with experts from the several involved domains (Fig. 4).

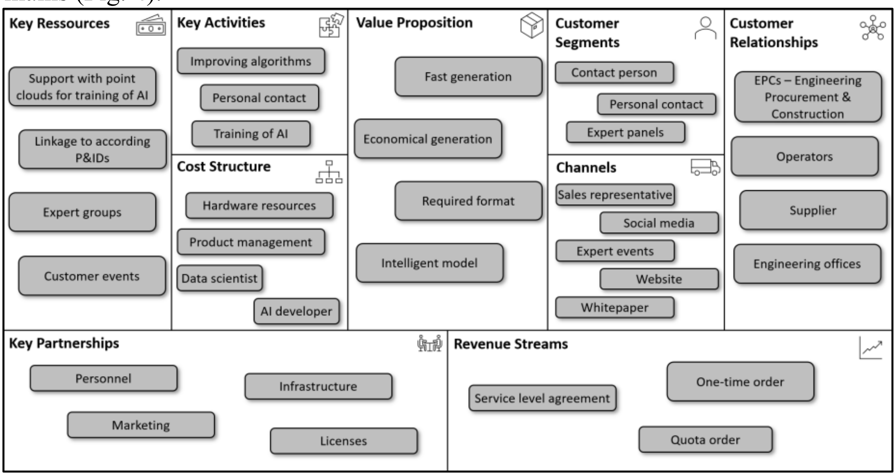

Figure 4. The business model canvas, derived from [12].

The value proposition is an automated generation of a digital twin covering 3D or spatial information of a brownfield plant. By exploiting AI, object recognition within the point cloud is achieved. This makes it possible to generate 3D digital twins more quickly and affordably than is now possible with manual remodeling options on the market. The result will be provided in the desired format for the customer. An intelligent model can be produced by applying the customers' specification in terms of piping class.

Operators of process plants assign so-called EPCs (Engineering, Procurement, and Construction) to coordinate and complete necessary tasks from planning through completion. Also, they are responsible for modernizing an existing plant. A CAD model of the specific brownfield plant's as-is condition is required as the starting point for the planning of the new parts. Operators are also interested in accurate documentation of their assets in their current state. Also, these digital twins can help engineering firms, service providers, and suppliers, for example, in maintenance activities, to provide a stronger and more accurate foundation for the planning of their tasks.

Key partners are required to guarantee a sufficient implementation of the service. In order to recognize objects from point clouds, AI must first be trained. Therefore, the preparation and usage of point clouds of plants from the process industry must be ensured. The point clouds can be accessed thanks to key partners who support the new service solution. These key partners are eventually replaced by customer point clouds since they naturally enhance the AI's capabilities as they are processed. Partners with additional competencies can broaden the offering in addition to creating 3D models. In this way, the piping system of a plant's CAD models can be connected to the corresponding P&IDs.

The AI's development and training play two crucial roles. On the one hand, an AI developer must put the algorithms into practice, including training, optimizing, and developing the AI. Accurate data science is a necessity for adequate training. The data scientist, who is in charge of preparing the point clouds needed for training, serves the second important role in this regard. To ensure optimal training results and the creation of a solid AI data model, these datasets must be prepared with the utmost accuracy.

5. Customer’s views of the digital twin

An important investment is prompted by the digital twin. A sophisticated system must be introduced over an extended period, which ties up resources [13]. Regular upgrades are supported by the digital twin, which typically interferes with day-to-day operations. Running the digital twin requires the right personnel. These are the pricing factors that could influence customers' choices about the introduction and use of the digital twin. As a result, when defining and using the digital twin, the needs of the customers must be taken into account and turned into explicit requirements that a service must meet [14]. Customers' demands should cover various methods for creating a digital twin and their use cases, and they should largely be supported by value streams that arise from cost reductions, time savings, and quality improvements [11].

It is vital to collect all relevant data into a unified framework in order to accurately reflect a real system in a digital twin. This also includes information on operating settings, inspection, and maintenance procedures, in addition to data or simulation models. Information can be utilized to illustrate the relationships between a digital twin's elements. In order for the algorithms to utilize this data, it must be stored, converted, and fed into the digital twin [15]. Real-time data fusion across many interfaces, data formats, and sources continues to be a big challenge [16].

An appropriate infrastructure must be set up in order to ensure continuous and automated data transfer to the digital twin. Its infrastructure consists of a fast, secure internet connection that allows real-time information processing and transfer [17]. Before the various systems are aligned with one another, setting up the infrastructure can take some time. A digital twin should also be flexible enough to accommodate upgrades and significant improvements. [8].

Conditions changes and new sensor data should be able to be easily modified directly in the digital twin. Any replacements for specific systems or components should also be immediately stored in the digital twin. It always has a singular identity, relates to a single physical thing, and gathers data during the object's full appearance [18]. The digital twin can then access information from other physical twins of the same object in this way. If an error occurs during the process, finding the root of the issue and a fix can be done more rapidly on a different product [19].

Another tool for training a digital twin is artificial intelligence. Based on operating data, these techniques can be utilized to recognize distinctive behavioral patterns and spot potential disruptions. In order to establish a consistent condition, it is necessary to connect the many physical and digital models. In our situation, the main issue here is the recognition of specific objects and their characteristics [13].

The data within a digital twin must be prepared appropriately in order for each stakeholder to obtain the information they require to take the necessary actions. A protection of the digital twin from unauthorized access must be ensured because it contains all of the recent and past data of a physical system. Just the information that each user profile is permitted to see or receive should be accessible to other user profiles [20]. There are recognized requirements for the digital twin of an operational process plant [21]:

1. The elements of the plant that are important for retrofitting are precisely captured by the digital twin.
2. The information from the source, which is often available at an industrial site, can be used to create the digital twin.
3. A digital twin should only require a little amount of manual setup.

Below is a summary of the requirements from the expert survey for the updated digital twin of a process plant:

- The customer's necessary pertinent information is recorded by the digital twin.
- The digital twin gives information on the real state of the plant that is specific to a certain use case, e.g. [22].
- The obstructed objects can be listed by the digital twin.
- The solid bodies' spatial information is generated by the digital twin.
- The corresponding metadata is included in the digital twin. (e.g., geometric information, administrative information, material information, etc.).

6. Customers' demand for a digital twin

The adoption of a digital twin in an industrial digital environment is justified by several advantages that it provides. For instance, the digital twin makes it possible to consistently document a plant's processes throughout its entire lifecycle. In this manner, a more accurate statement regarding the modernization, optimization, or replanning of a plant can be made. Better maintenance may be enabled through the combination of planned, historical, and present data [23]. Due to the availability of inspection or maintenance schedules, plant maintenance can also be made simpler.

Customers can be supported in a variety of use cases by a digital twin. As a result, requirements that meet customers' requirements can be developed. The requirements for a digital twin are discussed below starting from the conceptual design's foundation and origin. Following this needs analysis, it was decided to launch work on creating a complete or incremental digital twin of a process plant. There are four known use cases: (1) as-built documentation, (2) virtual operation and training, (3) modernization, (4) maintenance support by augmented reality, which serve as an example of the wide range of potential uses for digital twins in the plant industry and can be further merged to generate new use cases.

Table 2. Pertinent use cases for Digital Twin.

Use Cases	Main Characteristics
As-built document-tation	Over their lifecycle, the status of the plant is constantly changing as a result of ongoing maintenance, repair, and modernization efforts [24]. The documentation, and especially its updating, frequently needs improvement. A system that digitalizes a plant and continuously undergoes changes affordably is required to guarantee a frequent update of a twin. This necessitates a technique that works like an automatic update and is used as often as required. The foundation for ensuring an accurate 3D digital representation of a plant rests on this, which also makes the following use cases possible.
Virtual operation and training	Virtual operations and training are two examples of the support of field engineers who might receive training on it in this way before working at a particular plant. When access to a specific plant is difficult, such as with offshore operations, virtual training is used. Also, the likelihood of accidents is decreased if engineers get training before gaining access to a plant. Engineers can explore the plants and get familiar with them by using an avatar [25] to navigate through the plant, control equipment like valves, and monitor variables like pressure. The engineer can virtually walk through the plant to the desired valve and operate it there if the procedure calls for closing a valve. The virtual valve is connected to a real plant's physical valve. Electronic processing of the control commands causes the physical valve to respond as instructed by the command [15]. Furthermore, the models can be connected to P&ID and further enhanced with plant sensor data.
Moderni-zation	When a plant needs to be modernized, as-is documentation or a description of the real situation in terms of a 3D model is necessary. The planning processes for modernization are based on these principles. Many times, only a portion of a plant is replaced while the rest is left alone. It must be assured that the newly developed parts are compatible with the plant's other components. So, to create a digital 3D model of the actual plant today, 3D models are manually modified. This results in a very high-cost share that may be decreased by an automated digital twin generation process.

Use Cases	Main Characteristics
Maintenance support by augmented reality	To support maintenance tasks, a variety of information is required to enable augmented reality, e.g. by a combination of many sources. The plant's constituent parts must be fully understood and distinguished. A 3D representations let the field engineer immediately comprehend a component's structure. Metadata can be added. The connection of a 3D model of a component and meta-information gives a field engineer the context for maintenance. Changes can be documented simultaneously using a mobile device. The printed P&IDs contain information about replacement parts, in addition to keeping the corresponding CAD files up-to-date. A digital twin contains all pertinent data and places it all in its proper context so that it can be used with augmented reality. Immersive experiences have grown in popularity as a form of employee training due to the possibility of training without being exposed to these risks and practicing tasks safely (in the virtual environment, which in the real world would be too dangerous or impossible to perform, and very expensive to organize or reproduce) [19].

7. Conclusion and outlook

Many stakeholders in the process industry can profit in different ways from the concept of the digital twin. especially when taking into account a 3D representation of the current state. Nowadays, it is necessary to manually renovate the assets, which is both time-consuming and costly. Only use cases that offer more cost savings than those associated with modifying the assets are considered 3D representations. A corresponding business strategy must explicitly state the benefits [26].

A frequently manual generation is too expensive and 3D digital twins are not available for them, even though a variety of use cases could benefit. Then, for a plant to be represented in its current form, 3D digital twins require a continuous update. As a result, it is a repeatable activity that may be completed progressively as needed and may involve several process plant units. Stakeholders can use digital twins for further use cases, such as maintenance, modernization, virtual reality, and augmented reality, thanks to the automated development of a digital twin with spatial information [27].

Significant benefits must be offered to the customer by the envisaged service . It is necessary to describe how a particular solution is positioned in the market and to name competitors in order to define an appropriate business model. A solution that offers the automatic generation of a digital twin with spatial information can be devoted to the area of the blue ocean, according to the method of the buyers experience matrix. [11]. The solution contributes to the buyer`s experiences in a way that the solution provides major benefits to the customer which easily can be quantified [28].

The business model has been shaped and then improved by using the business canvas method. Consumer profiles within a specific group have been identified, and the value offer has been defined. Together with the client relationship and access points, the income stream and expense structure has also been established. To guarantee a successful solution offering, essential partners, key roles, and important resources have also been identified.

As shown by the market research, market observation, and customer interviews the resulting business model takes into account the existing ecosystem [14]. The solution will change as a result of expert feedback, and the product can be modified or enlarged. Also, the addition of new customer segments and the potential need for new order forms and income streams can all result from branch development. The business model must be revised or modified in such circumstances.

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