Digitization – Perspectives for Conceptualization

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Abstract. Digitization is more than using digital technologies to transfer data and perform computations and tasks. Digitization embraces disruptive effects of digital technologies on economy and society. To capture these effects, two perspectives are introduced, the product and the value-creation perspective. In the product perspective, digitization enables the transition from material, static products to interactive and configurable services. In the value-creation perspective, digitization facilitates the transition from centralized, isolated models of value creation, to bidirectional, co-creation oriented approaches of value creation.

Keywords: Digitization · Value co-creation · Digital business processes · Digital enterprise

1 Introduction

Digitization has a disruptive impact both on markets and the world of work and social structures [1]. The impact of digitization on the economy can be observed by the emergence of new companies [2] and the demise of established companies [3]. Therefore, it does not surprise that digitization is one of the most intensively discussed concepts today. Digitization is considered as an integral concept of modern management [4] and in the center of public interest [5]. Digitization is also top-priority topic of IT-Management [6] and business process management [7]. Numerous studies from renowned organizations and companies develop strategies in order to drive digitization [8, 9]. Studies predict enormous benefits through the introduction of digitization [8, 10]. An economy shaped by digitization, a digital economy, has already been sketched in [11]. Furthermore, digitization shall improve business processes in many industry sectors outside the information technology like the manufacturing industry [12]. Innovative approaches using digital technologies can also be found in areas such as tourism [13].

There are many definitions that consider digitization as a primarily technical term [14]. Technologies often associated with digitization [15] are: cloud computing [16], big data [17] and [18] advanced analytics, social software [19], and the Internet of things [20]. Also some new technologies are associated with digitization. For example, deep learning [21] allows computing to be applied to activities that were considered as

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exclusive to human beings [22]. Digitization is also tightly connected to the flexible execution of business processes [23]. Some authors consider digitization as caused by the exponential growth of computing, storage and networks that have surpassed certain limits [22].

Despite the widespread use of the term digitization there are only few definitions that try to capture the nature of digitization beyond the technological level. Nevertheless, the first approaches to analyze the non-technical perspectives of digitization are also rather old [24]. The definition in [1] identifies two aspects of digitization: the networking of people and things, second the convergence of real and virtual worlds. Other definitions [14] associate digitization with the creation of new opportunities that break down industry barriers and at the same time destroy existing business models [14]. Key elements of digital transformation strategies are described in [25]. In [26] scope, scale, speed and the sources of value creation and capture are identified as key themes for digital business strategy.

Our thesis is, that a definition of the term digitization requires multiple perspectives beyond the technical one. To do so, we introduce two new perspectives, the product and a value-creation perspective into the definition of digitization: Digitization changes the nature of what is called an product. It also transforms value-creation.

Our research method is a conceptual (non empirical) driven research approach [27] based on the current literature in the field of information systems, computer science and management with the focus on digitization. Adapted from the analyzed literature with regards to different influencing factors and basic principles, we create a framework of digitization.

The paper proceeds as follows; first, the technologies enabling digitization are described. Then we introduce two new perspectives for the definition of digitization. First we investigate how digitization impacts the notion of a product. In the following section, the transformation of value-creation will be analyzed. In the following chapter, some effects of the present wave of digitization will be depicted. Finally, an outlook and conclusion is given.

2 Technological Enablers of Digitization

Digital technologies exist since the 1940s. The digital representation of information, its processing and the term digitization, is in use since years [11]. Since the 1960 there is an ongoing exponential growth of the processing, storage and communication skills of modern IT systems [22].

The growth dynamics is described by Moore's law [28] formulated in the 1960s and 1975. It postulates a doubling of chip complexity every two years [28]. Moore's law is still applicable and Intel estimates it will be valid 10 years down to a structure width of 5 nm [29]. Significant economic benefits are associated with these technological advances. For example, an Internet application that caused costs of $150,000 a year of the year 2000, cost only about $1,500 in 2011 [30].

Digitization today is associated with a number of technologies, the most prominent are: Big data [17] and advanced analytics [16, 18] cloud computing [16], social software

[19], and the Internet of things [20]. In the future, it is expected that new potential for digitization is created by the automation of supporting tasks that require dexterity, natural language understanding, pattern recognition and case based problem solving [31].

2.1 Big Data and Advanced Analytics

Big data [17] and advanced analytics [18] have received much attention in industry and research [32]. Big data is not a specific technology or platform such as Hadoop [33], but describes a series of technological advances that made possible a significant improvement of decision support in business. Big Data can help organizations to improve current business processes and to be more competitive [34]. Before the emergence of Big Data, decision support was based on structured data from internal sources, as shown in Fig. 1. This data typically originate from business transactions and are usually maintained in an ERP system. Due to their normalized [35] structure, these data are of limited used for analytics. Therefore approaches such as business analytics [36] and business intelligence [37] move and transform these data using into a data warehouse using an extract, transform and load approach. The use of intermediate data creates considerable latency from the emergence of data to their visibility into the data warehouse. Therefore, the analyses carried out are mainly backwards oriented and have a descriptive perspective. On the contrary, the approach is of limited use for decisions that require an immediate response.

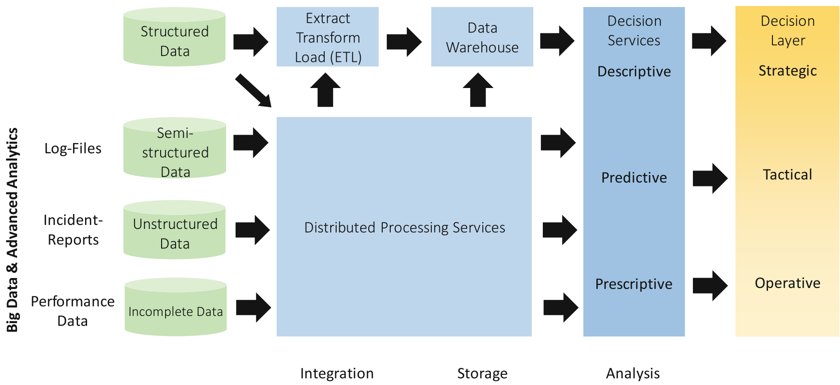

Fig. 1. Big Data extending Volume, Variety and Velocity based on [38]

These constraints and the emergence of always larger sources of unstructured and semi-structured data led to the development of big data and NoSQL technologies [39]. Semi structured data, e.g. log files of Web servers, have no explicit schema as data in a relational database [35]. Unstructured files, e.g. customer comments in a Web blog, have no schema that can be reconstructed. Semantic heterogeneity is another characteristic of semi- and unstructured data.

The processing of semi- and unstructured data is very computing-intensive. Therefore classic database concepts with a centralized architecture [33, 35] are quickly overwhelmed. On the contrary, highly distributed approaches such as Hadoop, allow to process semi- and unstructured data in the Petabyte range [33]. An important effect of distributed computing is the significant reduction of latency between the emergence of the data and the analysis. The inclusion of large amounts of data allows to create also predictive or even recommending analyses. Due to the reduced latency decisions on tactical and even operational level are supported.

2.2 Cloud-Computing

Cloud computing is implementing the vision, that computation and storage is available in the same way as the electricity and water supply, also called “utility computing” [40]. A significant increase in efficiency is achieved by economies of scale. The most widely used definition of cloud-computing from the National Institute of standards (NIST) [16] identifies five characteristics: self-service, a high-performance network access, resource pooling, elasticity, and billing after consumption. The NIST definition distinguishes three service models: software, platform, and infrastructure as a service. In addition, four usage models are defined, namely the private, public, hybrid, and community cloud. Cloud-Computing also generates new economic advantages for enterprises [41] and can be used to be more customer-oriented as well as improve customer relationship management [42].

2.3 Social Software

Social software and its underlying concepts can be found today in many areas, both in the public sector, in the form of social networks [43] as same as in organizations applying approaches like Enterprise 2.0 [44]. The success of social software is based essentially on three basic concepts that significantly reject existing organizational concepts. There are weak ties [45], egalitarian structures [46] and social production [47].

In social production, the role of the individual during production is not defined in advance by management. Instead, the individual makes his contributions in the interest of a high social reputation. No hierarchical structures are necessary to coordinate work or to ensure a high quality. Weak ties [45] are links between people, created by incident outside the established organizational structures. An example is the use of the same blogs. Weak ties can be used to assess the impact of a negative statement about a product. Egalitarian [46] structures assure, that no important contribution is excluded due to a low hierarchical position of the contributor.

2.4 Internet of Things

“Internet of Things” is according to Gartner, the most hyped term 2014 [5]. The basis is that growing miniaturization allows implementing always-richer functionality in a small space. Sensors, actuators and RFID [48] are the starting points of the development of the internet of things. Today powerful processing, storage and communication capabilities have been added, allowing the performance of office PCs of the early 2000s on a credit card to assemble machines such as the raspberry pi 2 [49].

3 Product Perspective

3.1 Digitized Products

Digitized products differ significantly from the physical products shaped by the paradigms of Taylorism [50] and Fordism [51]. An often-standardized hardware captures the environment using sensors and acts through actuators on them. It is controlled via software, which is updatable and in this way customizable and extensible. The device is in connection with other devices or Cloud-based systems via communication networks. The device may use the services provided in the cloud and sends data to these services (Fig. 2).

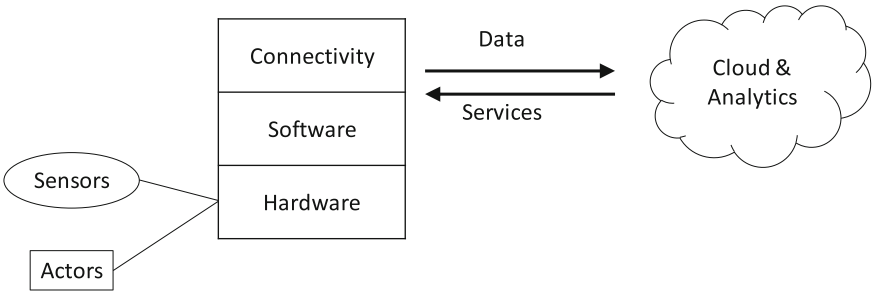

Fig. 2. Digitized products

To enable future extensions, hardware capabilities are designed in a generic way: the functionality of the device is shaped by the software and the cloud services as far as possible. The hardware provides only the necessary processing, storage, and communication skills. Furthermore, external devices are used to complement functionality in quickly evolving technologies. An example is the use of tablets and mobile phones as a substitute for attached displays.

3.2 Digitized Products Are Reflective

Digitized products are constantly in communication with the manufacturer. In this way, the manufacturer can collect genuine information about the use of the product. This collection of data can be done with involvement of the customer. Important information for the development of new products can be obtained. In addition, it is possible to identify up- and cross-selling chances. Based on the data collected higher value offerings or additional offerings can be identified, which are beneficial to customers. The fact that the customer did not realize these needs on its own will also strengthen the relationship of trust with the manufacturer. In the same way, functionality can be identified that is no longer needed by the customer. This information can be used to submit a cheaper deal based on a reduced functionality to the customer. Abstracted from the individual customer, important information can be collected. It is possible to use these data for the segmentation of customers and the identification of customer needs.

3.3 Digitized Products Are Dynamic

The classic industrial products are static [52]. After production, you cannot change the product at all or only to a limited extent. Digitization creates products containing software that can be upgraded via network connections. In addition, digitized products can use external services. Software and especially services are easier to update. New software functions can be added; additional services can be integrated. Therefore, the functionality of products is no longer static, but can be adapted to changing requirements. In particular, it is possible to create step-by-step or temporarily unlockable functionalities of the product. So, customers whose requirements have risen can add functions without hardware modification.

3.4 Digitized Products Are Servitized

The digitization enables products to capture their own state and communicate it to the vendor. By this means, the vendor is able to determine remotely whether the product is still functional and encourage, when appropriate, maintenance and repairs. This is the basis on which the product can be offered as a service, instead of the physical product. This transformation is called servitization [53]. Such services will be measured based on their availability. Examples are guaranteed machine availability, energy savings or crop yields.

By providing a service to the user and not selling a product to a consumer, usage-based billing models can be established (related to public cloud computing [41]). In addition to the usage information also the condition of the product by the manufacturer can be queried and the product informs the manufacturer about critical status changes.

In this context, concepts of preventive maintenance can be developed. These have the objective of to avoid unscheduled stoppages whenever possible. Evaluation of status information and analysis of the history of use of the product allow to predict, when a malfunction of the product is likely. Then, a maintenance or replacement of the product can be performed before the respective date. In this context, the collected data can also be used to provide preparatory information for a repair, so that a high first time solution rate can be achieved. At the same time, storage of spare parts can be minimized.

4 Value-Creation Perspective

To encompass digitization from a value creation perspective, one has to start with the paradigms that governed industrial production before digitization: Taylorism [54] and Fordism [51]. Both paradigms coined the character of industrial products: They are produced isolated from the customer in huge quantities in order to create economies of scale. The single point of interaction between vendor and customer is the exchange of the product against the payment. After the payment the vendor has normally no contact with the product anymore. The product preserves its configuration until it is broken our decommissioned. Products created in such a setting do not communicate either with the producer, among each other or with other objects. Digitized products however, are able to communicate with the producer and their environment. Thus a number of new mechanisms for value creation are provided.

4.1 Platforms

Platforms are complementary products, which cooperate via standardized interfaces [55]. Software platforms support the collection, analysis and exchange of data [52]. Platforms significantly speed-up the development time of new solutions, since the development of new functionality is distributed on different partners [56]. At the same time also a distribution of the development effort and risks takes place [56].

Up- and downward spirals are characteristic of platforms [34]. Attractive platforms attract many customers. This in turn makes the development of additional functionality through new partner attractive. Newly developed capabilities in turn increase the attractiveness of the platform for customers, etc. On the other hand, unattractive platforms lose customers, which, reduce the incentive to develop extensions for these platforms, in turn.

The physical devices in a platform [34] also significantly increase the switching costs for customers. The customer cannot move his equipment to another platform. He loses not only his device, but he must write off the purchases of additional functionalities such as apps. Finally, the customer loses the individual adjustments made by him such as configurations and settings etc.

4.2 Network Effects

By linking devices on networks, benefits are generated from two areas. Both the functionality increases and there are positive effects arising from the overarching data use. Network effects grow exponentially, because they are based on the number of participants, but on the number of possible connections.

The possibility to connect devices of the network increases the possibilities of the individual device, because the number of potential partners increases. By these means, extra value is created that increases faster as the number of devices, since the number of possible connections grows faster as the device number [57]. Furthermore, this makes it easy to provide integrated solutions to the customer that provides solutions over the whole lifecycle. Services provided by a lot of partners with complementary skills [52] may create extra value.

4.3 Networked Intelligence

By linking data from different sources [58], it is possible to detect correlations that would not have been possible to detect with the data of a single device. This effect increases with the number of devices. Therefore, network effects become apparent not only in functionality, but also in the scope of the data. These effects are called network intelligence [24]. Trends can be detected much earlier and more accurately by bringing together data from different network nodes. A characteristic is the involvement of individual product in an information system, which accelerates the learning and knowledge processes across all products [18]. In this way, a number of other beneficial effects can be achieved as network optimization, maintenance optimization, improved restore capabilities, and additional evidence against the consideration of individual systems. Furthermore, extraction of relevant information can be also improved by integrating external data sources.

4.4 Co-creation of Value

The prevalent model of the economy is based on physical goods. Starting point of thinking is the consideration by Adam Smith in his work "The Wealth of Nations" [59]. Here, the market-based exchange of goods enables the specialization and the division of labor production, which leads to a higher overall efficiency. Following this basic orientation also the Taylorism [50] and Fordism [51] are designed.

Central to this thinking is the idea that the producer of goods creates value. The value is determined at the moment of exchange of goods. It had been tried to transfer this idea on services. However, this led to a service definition, which considers services as a negation of physical goods [60]. E.g. services are not material, they are also not divisible, i.e. they must be provided as a whole. Services are also not durable; they cannot be stored and are provided only at the moment of need.

To break this thinking, Vargo and Lusch have developed an alternative design. In the service-dominant logic [61, 62] not goods, but service is the center of economic exchange. Goods hide only the fact that economic exchange actually concerns an exchange of services. Goods are used to materialize services [62]. An example of this is the television set, it used to be for a long time synonymous with television. Today, there are very many different ways to watch TV.

Consequently, the view changed how to determine the value of the service. In contrast to the goods dominant logic the value is determined during use of the service instead of the moment of purchase [62].

Basis for the implementation of service-dominant logic by digitization is the continuous connection of the products with the manufacturer. The manufacturer can win genuine information about the use of the product. Important information for the development of new products can be obtained in this way. The consumer becomes a prosumer [63]. Furthermore, digitization allows collecting information about the customer's preferences. This information can be used to facilitate choice for the customer. An example is Amazon [31] that is offering nearly 10 million different products but enables the customer to quickly find a product and select a vendor by giving recommendations to the customer, collecting evaluations, customer reviews and vendor evaluations. Another example for a sector, which could generate a high advantage is tourism [13]. Modern technologies like VR and also AR could help to improve the service through data driven applications and increase the additional value for the customer [13]. Combining these entire tools enable the customer to find the desired product more easily than in a physical shop (Fig. 3).

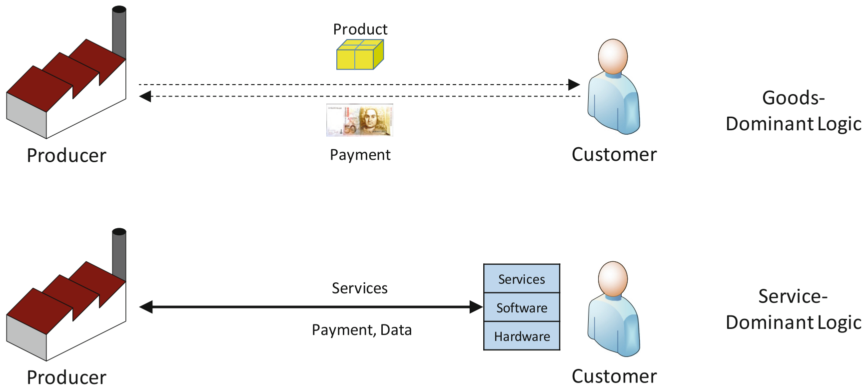

Fig. 3. GD-Logic versus SD-Logic

One could assume that an abundant offer of products and services is valued by the customer. However even small experiments show, that much choice both attracts the customer but also reduces his propensity to make a deal [64, 65]. In general complexity is perceived as negative from a customer's perspective [31]. In consequence, there is a trade-off between complexity and the value created [31]. Digitization is able to reduce complexity especially for the customer and thus increase value-creation by decoupling product and process complexity [31].

In former times, it was assumed, that the direct and personal contact with the customer is the best approach for increasing customer loyalty and revenues. Nowadays an increasing percentage of customer, especially between 20 and 30 years old prefer online touchpoints [31].

5 Conclusion

Digitized products have new capabilities to interact with their environment and the customer. These capabilities embrace sensing, physical interaction, data-exchange and service delivery. We designed a framework for digitization in this paper to get a better understanding. Based on technologies such as Big Data, Cloud-Computing or the Internet of Things, digitization enables the creation of dynamic products that appear more as a service than a device to the customer. Digitized products can be used as data hubs for collecting information about themselves and their environment. The connectivity of digitized products enables network effects and networked intelligence. A significant change of value creation is initiated by digitized products. The so-called Service-Dominant Logic becomes more and more the governing paradigm of economy. Value-creation becomes bidirectional.

We contributed to the current information systems literature in different ways. We defined important aspects of digitization and linked it to each other. Furthermore, researchers can start to empirically evaluate our framework and get a better understanding of digitization. Managers can use our framework to evaluate their business work to become a more competitive organization trough digitization. This is of particular importance because strategy, culture and talent development are more decisive for digitization than technology [66]. Management should focus on reconfiguring the business to take advantage of digital technologies instead of trying to find the most appropriate technology. Winners in this environment will be companies, enable network effects to create value for the customers [52]. Digitization also affects economy and society as a whole [67].

There are some limitations to discuss. Our framework is based on literature work. There is no deep empirical validation until now. Furthermore, industry-specific differences are not described in a detailed way. Therefore, future research should validate our framework trough qualitative and quantitative methods (e.g. expert interviews, experiments, and survey) and explore industry-specific differences.

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