Architectural Considerations for the System Landscape of the Digital Transformation

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***Abstract*—Since the advent of the World Wide Web the latest, there is a growing adoption of digital media for different purposes. It started with mere consumption through information and entertainment services, and expanded to the engagement of users with service providers in commercial and governmental affairs. As a consequence, services are extended into different directions: the communication channels used by clients, the improvement of services by including information on users and usage contexts, up to the goods or services in themselves that are being delivered. To this end, established processes, even ones at the core of a company's value adding chain, have to be thought over, optimized, or even restructured. The importance of these kind of adaptations for current enterprises led to the coining of the term *digitalization* or *digital transformation* for them. Since systems for the support of digitalized processes consist of many products and services that are assembled or coordinated, a consideration of their overall system architecture is required. In face of ready-to-use solutions that are available for specific functionality, and also of the availability of larger ecosystems that enable digitalized processes, often the architecture is dictated by the components that are available in practice. Architectural considerations that start with requirements and constraints instead have to be applied in order to achieve the engineering quality of other software solutions, and to meet non-functional requirements like maintainability. The contribution of this paper is a first step into that direction. It starts with an analysis of typical functional requirements of systems for the support of digitalized processes. From these, it presents a first approach to an integrated architecture for digitalized systems, and it maps requirements to common software components and services that typically implement parts of the architecture.**

Keywords*—Digitization; Digitalization; Digital transformation; Software architecture; Systems architecture; Solution architecture; Enterprise architecture.

I. INTRODUCTION

Since the advent of the World Wide Web the latest, there is a growing adoption of digital media for different purposes. It started with mere consumption through information and entertainment services, and expanded to the engagement of users with service providers in commercial and governmental affairs. Services, to this end, are extended into different directions: the communication channels used by clients, the inclusion of information on users and usage contexts into service delivery, up to the goods or services in themselves that are being delivered.

Nowadays, practically every business is required to offer information, fulfillment (e.g., sold goods or delivered services), and support over the Internet through its website, specific apps for touch devices, social media appearances, etc. [1] This requirement is not limited to digital goods. In fact, it has long been extended to the real world. Companies engage with clients through digital services in ways that are oriented at the clients' needs and preferences. This includes the choice of communication channels, as well as channel changes in the course of a process, or even the process as a whole.

The increased engagement of clients with service providers in conjunction with both the fact that demands are posed by the clients and the need to rethink processes led to the coining of the term *digitalization* or *digital transformation* for the wider approach. Its importance is underlined by the facts that most parts of the IT industry are now working in the field of digitalization and that some governments devised action plans to encourage digital service improvements.

There is no rigid definition of what digital transformation is or what it includes. Sometimes, the terms *digitization*, *digitalization*, and *digital transformation* are interpreted as three aspects of the transformation of processes [2]. One attempt by Gartner for a definition is "the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business." [3]

Technology is, therefore, an important driver for such business goals. In addition to its classical functions as computing machinery, data storage, and communication medium, the further employment of data and IT infrastructure forms the basis of the digital transformation [4]. With respect to systems support for client interactions, these require going beyond the mere utilization of IT infrastructure for the support of established processes. Quite the opposite, established processes, even ones at the core of a company's value adding chain, have to be thought over, optimized, or even restructured [5] in order to reach the new goals.

Since systems for the support of digitalized processes consist of many products and services that are assembled or coordinated, a consideration of the overall architecture is required. In face of the ready-to-use solutions that are available for specific functionality, and also of the availability of larger ecosystems that enable digitalized processes, often the scope and structure of applications are dictated by the components that are being used. This is an observation that can be made in practice, similar to Conway's law.

A return to old values of systems architecture seems due in order to construct systems based on requirements and with the aim of business value, not the other way round. Furthermore, taking a software engineering approach to the construction

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of systems for digitalized processes allows achieving the engineering quality of other software solutions, and it allows meeting non-functional requirements like maintainability.

The contribution of this paper is a first step into that direction. It starts with an analysis of typical functional requirements to systems for the support digitalized processes. From these, it presents a first approach of an integrated architecture for digital systems, and it maps requirements to usual software components and services that typically implement parts of the architecture.

The rest of this paper is organized as follows: The scope of the digital transformation is outlined by Section II. In Section III, we give an overview of the functionality that is expected from modern IT systems of digitalized institutions. Section IV presents a selection of software systems, services, and components that deliver such functionality. The paper closes with a summary and an outlook in Section V.

II. Digitalization of Enterprises

The introductory section already introduced characteristics of the digital transformation. Further characteristics and technological considerations follow.

A. Digital Transformation Goals

The digital transformation can no longer be handled separate from the "real world". Both physical as well as digital channels are used equally. Or, put the other way around: "Every business is now a digital business." [6]. Companies need to (actively) maintain customer relationships over all channels, processes must not be hindered by media barriers between channels, companies collect different data on product sales and on product use, etc. In essence, more and more of an enterprise's processes will be transferred to the digital domain. This is particularly important for, but not restricted to customer-facing interactions.

This paper concentrates on processes by which institutions interact with clients. In particular, it focuses on companies that interact with their customers and, therefore, on interactions and client engagement.

The paper does not, e.g., consider the digitalization of engineering processes (compare Computer-Aided Design, CAD, Computer-Aided Manufacturing, CAM, Computer-Integrated Manufacturing, CIM, and similar technologies). It does also not cover aspects of digitalization driven by recent technologies like, e.g., the Internet of Things (IOT), applications for Industry 4.0 [7], Radio-Frequency Identification (RFID), Near Field Communication (NFC), or Beacons to collect customer data through devices, and modern payment methods like crypto currencies.

An understanding of customers is derived, among other data sources, from information on *customer journeys*. They are formed by all (inter)actions of customer with respect to a current activity. For example, all web searches, web page reads, and commercial transactions connected to a purchase form the customer journey of buying a product. For a more fine-grained determination of the points of contact on a customer journey, Google proposed "micro-moments" that exhibit customers' intent, context, and immediacy [8].

On top of the technical abilities, further important factors for the ongoing transformation are the willingness of consumers to take part in a digital economy and to stay informed, even if this means putting some privacy concerns aside, as well as the recognition of potential economic benefits of digitization and the need to foster them [9].

B. Digital Transformation Technology

Since this paper focuses on interactions between companies with their customers, system support mainly consists of commerce functions like marketing, sales, and customer care.

There are many other aspects and opportunities related to the digital transformation. In particular, there are other technology-driven aspects of digitalization. Topics include, to name just two examples, big data, e.g., behavioral data (tracking, purchases, etc.) on customers, and artificial intelligence and machine learning approaches, e.g., to the analysis of big data [10].

A plethora of products and services for digitalized enterprises is emerging [11]. The "Marketing Technology Landscape Supergraphic" [12] visualizes this for 8,000 of them. Some of the products and services provide rather isolated functionality, some try to cover a larger portion of digitalization requirements such as integrated solutions like product suites or service collections (by some providers called *marketing clouds* or similar).

In concert, the partial solutions allow digitally transforming a company's processes at affordable cost. The application-specific combination of products and services allows companies to realize competitive advantages while keeping up with the state-of-the-art in communication with reasonable effort.

When the technical landscape that drives digital enterprises is realized by the composition of a range of components, there are many communication relations between them. Communication requires interfaces that ensure a coherent handling of data and its interpretations, a common understanding of customers in each of the components, etc. To this end, the architecture of such technical landscapes has to be defined.

III. High-Level Architecture Consideration

Without formally giving a definition for architecture, we start by studying functional building blocks of systems for digitalized enterprises. They are assumed to be the architectural building blocks of a logical architecture. In contrast to common practice, we do not want to start with the consideration of concrete components. We use the term *component* for both a software product and a service.

The aim is to be able to talk about requirements and solutions in general, to study functionality and dataflows. We want to avoid the premature assignment of responsibilities to services, and also the concentration on data exchange, data conversions, etc., as it is often found in practice.

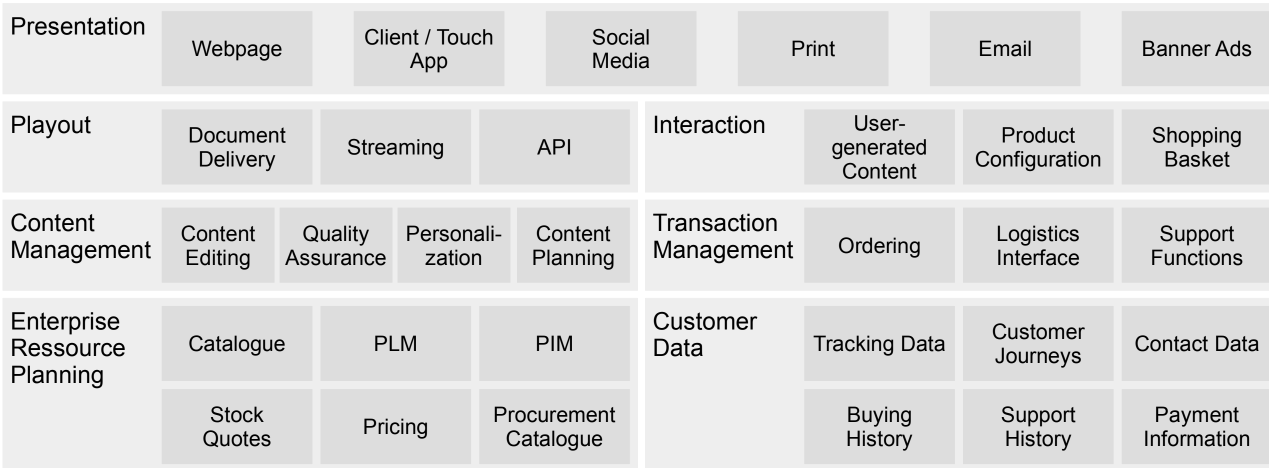

Figure 1. Functional building blocks of a high level architecture.

Figure 1 highlights some of the functional building blocks of an architecture. In the subsequent subsections, we study some of them. The outer boxes are arranged as a layered architecture in order to visualize service dependencies in general. In the vertical dimension, the lower components each offer services to the components that graphically are placed above them.

A. Content Publishing

Systems for digital enterprises often consider the World Wide Web (WWW) as one of their primary channels through which they communicate with their clients. Subsequently, many of these systems are centered around a *Content Management System* (*CMS*) or another web-based system. Figure 2 shows the components that contribute to a publishing process that addresses multiple channels.

A content management component primarily incorporates functionality to store and manage content. Often, structured (text and structure of text documents) and unstructured content (images, sound, moving image, etc.) are distinguished because of their different properties and the different functions associated with their management. Unstructured content is then managed by a *Digital Asset Management* (*DAM*) system.

Content management typically includes quality assurance. Some products achieve it by *content staging*. They copy content that is ready for publication to a specific component that delivers content to the playout components. Rules and workflows may be associated with quality assurance.

A *playout* component is employed to distribute documents that are created from content.

The receiver of such documents is a client that serves for their presentation. Interactive applications can also be found on this layer, e.g., JavaScript apps embedded in webpages or touch apps for mobile devices. For those, an API may be provided on the playout level that gives access to different services of the other components.

B. Personalization

By means of *personalization*, the documents and services that are delivered are individualized for specific users. *Targeting* is the approach to this that is found is practice most often. The component interplay for general personalization is shown in Figure 3.

Personalization can be applied on the level of content, as well as on the level of content representations. Content personalization is built into some CMS products. The personalization

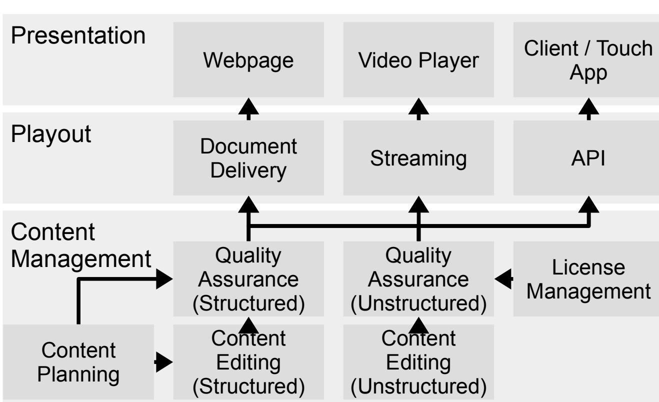

Figure 2. Content management components.

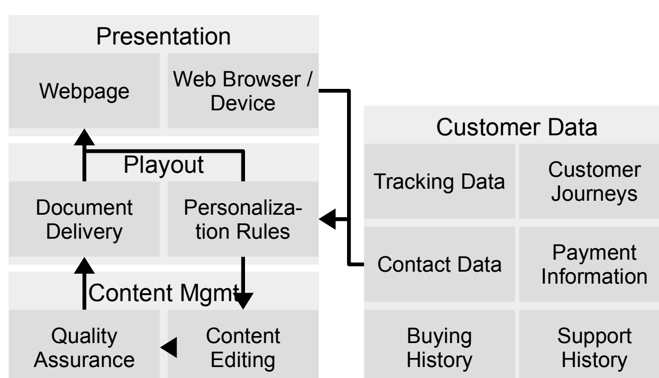

Figure 3. Components involved in personalized document delivery.

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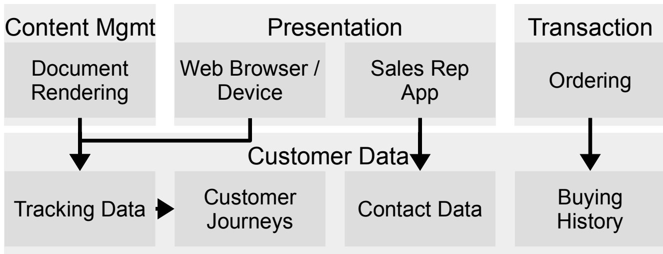

Figure 4. Components for the management of customer data.

of representations can also be fulfilled by a service that is provided outside the CMS.

On both levels, personalization is normally performed by evaluating rules on the basis on a classification of customers that is derived from their behavior [13].

Tracking is the most basic way to observe users' behavior. For content personalization, the utilization of pieces of content during document rendering is monitored. Accesses to web pages are typically recorded for document personalization. Tracking is performed by some (web) tracking or *tag management* service.

C. Consumer Data Management

One of the pillars of the digital transformation is the involvement of clients. Therefore, it is obvious that a company needs to know its customers and, therefore, collect data on them. This is done for two reasons: Firstly, the data is of value in itself, e.g., to be able to identify customers and prospects that might be interested in offers. Secondly, the data is used to fulfill services better.

An excerpt of an architecture for the management of customer data is shown in Figure 4.

There are multiple components available that collect information on users. The previous subsection already named tracking services as a source of data on customer behavior. Also, the commerce functions allow to access historical data, e.g., on past purchases. *Customer Relationship Management* (*CRM*) systems are the primary class of systems for customer data. These allow to structure customer information in order to record contact information, purchases and other interactions, the communication history, etc. A CRM is typically maintained by sales personnel.

In a digitalization scenario, a CRM system needs to be extended with the other sources of data about customers, and in particular the collection of information that originates from all channels the customers use. The increased user database is also called a *Customer Data Platform* (*CDP*).

The *sales rep app* depicted in Figure 4 represents a typical client-side software application that is used in sales talks, product presentations, etc. It uses material that is delivered by, e.g., a CMS, and it is typically used to create and update records in a CRM.

Another potential use of customer information lies in the extension of personalization and recommendations, often called *Customer Journey Orchestration*. It relies on the aggregated information collected on different channels, and it is used to personalize whole customer journeys, i.e., series of interactions at different touchpoints.

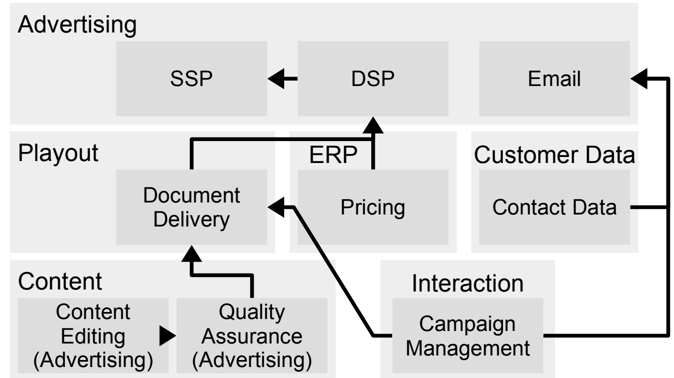

Figure 5. Retargeting components.

D. Retargeting

A customer journey may lead a user away from the digital touchpoints of a company (or some other institution), for example, to get information from somewhere else. Companies want to keep the users' focus user on their customer journey and to encourage the users to return to one of their touchpoints once they feel informed. The process of re-attracting customers is called *retargeting*.

One common means for retargeting on the web are adverts on foreign websites. For example, when a customer leaves a company's website and visits another one, a banner ad placed on that other one leads the user back to the company's website. In the best case, the ad is personalized for the customer [14]. The URL underlying the ad might, e.g., direct the user to a landing page for recurring users that displays a personalized offer.

Components and data flows for retargeting are shown in Figure 5. Ad servers choose an ad to be displayed on a webpage that offers ad space. They operate on a marketplace for ads on which companies register ads, and from which websites fetch one.

A service for the management of registered ads is called a *Demand Side Platform* (*DSP*). A company might use its content management systems (CMS and DAM) to manage publicity material and to hand it over to the DSP. Further information might include, also indicated in the figure, a rebated price for a personalized offer to be made by an ad, and a campaign key, so that the campaign management tool can measure the success of a retargeting campaign.

Websites that include ads retrieve them from a *Supply Side Platform* (*SSP*) service that chooses and delivers ads on demand. The SSP retrieves the ads from the DSP.

Another common tool for retargeting is email. This is also sketched in Figure 5. The campaign management tool triggers email delivery when retargeting is appropriate. The email body may come from a CMS, the recipient's email address from the customer data management system.

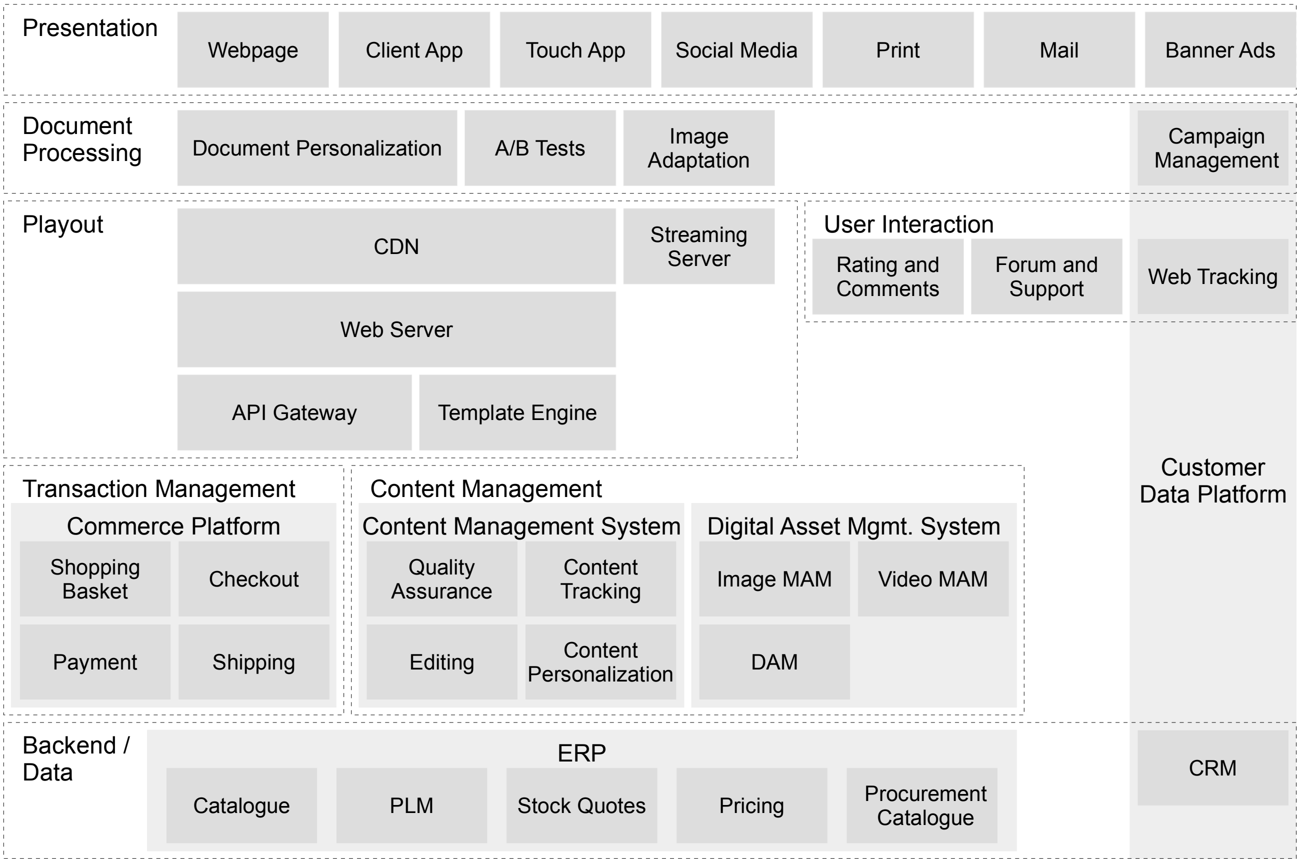

Figure 6. An exemplary system configuration for a digitalized enterprise.

IV. Architecture Building Blocks

A logical architecture that describes functionality as outlined in the preceding subsection is mapped to concrete components for implementation. In order to distinguish the logical view on the architecture from a component view that describes system implementation, we call the implementation model a *system configuration*.

A system configuration mainly consists of a selection of components and services, parameterizations and customizations of the components, the communication between the components, as well as interfaces to the environment.

Figure 6 gives outlines the structure of a high-level system configuration. The dotted lines outline functional units as they have been considered in the preceding section. The outer gray boxes depict software products and services that are employed to implement functionality. This way, we relate the two architecture views – abstract functionality and concrete implementations – in the figure.

Each implementation unit may be delivered by a single component, an assembly of components, or separate components that work in concert. Therefore, there are lots of integration tasks for a configuration. This may be one strong argument in favor of marketing/sales clouds that offer integration out of the box. Alternative approaches are an integration platform and a central integration bus. But these solutions are rarely found.

Instead, a lot of point-to-point integrations are found in practice. These may be implemented in different ways. Through tight coupling, the systems may use the same data by sharing storage, by exchanging data, or by one using the other as its storage. With loose coupling, one component offers services to another.

There are well-established principles that guide the assignment of functionality to components and the choice of the integration approach. A prominent example are the principles of high coherence and low coupling. High coherence is important to avoid redundancy as much as possible, of both functionality and data. Low coupling supports non-functional properties so that, for example, services of a certain kind can be chosen dynamically, and components can (horizontally) be scaled.

As an example for implementation alternatives, the integration of a CMS with a DAM has thoroughly been studied in an earlier publication [15]. In this case, content management functionality like quality assurance and content transformations are offered by both kinds of components. Therefore, the responsibility for the according tasks has to be distributed. The (independent, but related) lifecycles of structured and unstructured content are another factor for the choice of the integration approach.

The CDP is another relevant example. There exist dedicated products and services for this component that may import data from the other components that collect data about customers.

A CDP may as well be realized by, e.g., importing web tracking and campaign tracking data into a CRM, or by an orchestration of the components.

Many systems have a notion of customers: the CMS through tracking and personalization, the campaign management through address lists, a commerce system through commercial transactions, the CRM system by keeping contact information, *Enterprise Resource Planning* (*ERP*) systems for accounts receivable accounting, etc. All these different perceptions of a customer need to be related to each other. If the related information is materialized in one aggregated record, this one is sometimes called a *golden record*. The records are handled through so-called *master data management*.

The same holds for the products or services a company offers. While product data are hosted by a *Product Information Management* (*PIM*) system, prices are calculated by a pricing engine based on data from the PIM, the ERP, or the commerce system. Additional product descriptions that are maintained for marketing reasons may reside in a CMS. Therefore, master data management is also required at this point.

V. Conclusion

The paper concludes with a summary and an outlook.

A. Summary

This paper presents the main requirements to system support for digitalized institutions. It focuses on commercial interactions between companies and their customers.

Current IT landscapes for digitalized enterprises are typically assembled from readily available software products and services. The architecture of the resulting systems often seems to be motivated by the selected components, not by established architecture principles. In particular, requirements are often formulated after the functionality of available components, and responsibilities are solely assigned on the basis of given functionality and the characteristics of available components.

This paper constitutes the starting point for a discussion on architectures for digital systems through which companies interact with their customers. In order to do so, we enumerate typical tasks to be performed by such systems, and we take an architectural view on such systems. By first designing the logical architecture, the system design follows requirements, not technical constraints. Such architectural considerations allow discussing different implementations of the requirements. Furthermore, non-functional requirements can be covered by system design.

B. Outlook

This paper presents insights gained from various digital transformation projects. As a next step, existing reference architectures have to be analyzed for further input on requirements, product and service categories, and solution patterns.

One future result would be an approach to architecture definition for systems for digital enterprises. It may be supported by checklists, templates for requirements and constraints, as well as solution patterns.

There are many well-understood cases from which it seems possible to create a generic pattern library for system constellations that have proven beneficial. This would include architectural building blocks, architecture principles, guidelines for the selection of products and services, etc. Such pattern libraries are at least within reach for specific cases or domains.

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