Digital Signage and Targeted Advertisement Based on Personal Preferences and Digital Business Models

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***Abstract*—Digital signage in general refers to the provision of content (advertisements, news, assistance) on electronic scoreboards or large displays in places where many people are present or passing by. The more this content is expected to be tailored for specific user groups, the more context information is required, like, e.g., the preferences or profiles of target users or user groups. The ideal digital signage solution would be able to provide individualized content for the audience consuming the information at any time: if only one person is present, the content would be personalized for this person; if a group of persons is present the demand of all should be met. Based on a digital signage solution for elevator doors, the paper investigates the intersecting of preferences as a contribution to determine the most relevant content for a group of users. This intersection of preferences serves as a basis for new business models for interactive elevator digital signage. The main contributions of the paper are (1) an industrial case of digital business model innovation motivating contextual digital signage, (2) a technical approach for intersecting personal preferences, and (3) a methodical approach for digital business model innovation.**

I. Introduction

Currently, advertising is usually targeted, i. e. it is aimed at specific interests and takes into account specific preferences of people. Recently, personalization has become one of the foundations of successful service provision [1]. Information "giants" (Google, Microsoft, Yandex, Uber, etc.) no longer hide the fact of collecting information about users of their software services. However, in this case the advertisement is focused on one user. In the case of advertisement targeted at a group of users (e.g., digital signage), targeting is associated with a number of problems. The problems of the highest priority are related to the identification of preferences / interests common to a group of people, as well as to their confidentiality.

This kind of advertisement can be referred to as contextual [2], i.e. the advertisement depends on the situation and the audience. Such advertising can be represented using electronic scoreboards installed in places where people gather (for example, shops, elevators, transport). In addition, information screens in companies, office centers, and transport can also work in this way, displaying information related to employees, visitors or passengers nearby. Thus, the paper considers the problem of identifying common preferences of a group of people taking into account their confidentiality for providing personalized contextual Digital Signage [3], [4].

The paper is motivated by an industrial project aiming at new business models and solutions for a specific type of digital signage: interactive content on elevator doors. In the context of this project, we were also able to study the process of digital business model development and a product implementing the new business model. From this product originate most requirements for our work on personalized contextual Digital Signage.

The main contributions of the paper are (1) an industrial case of digital business model innovation motivating contextual digital signage, (2) a technical approach for intersecting personal preferences, and (3) a methodical approach for digital business model innovation. The remainder of the paper is structured as follows: Section II briefly summarizes the research method used for the work presented in this paper. Section III introduces the industrial case studied in the paper and motivating the approach for intersecting personal preferences. Section IV introduces the proposed improvements and section V gives background information on preferences required for the improvement. Section VI proposes an approach for intersecting preferences. Section VII discusses related work and Section VIII summarizes the paper.

II. Research method

The research paradigm used for the work presented in this paper is the design science research (DSR) framework for information systems research proposed by Hevner et al. [5]. Design science is a problem-solving paradigm that reacts on an identified organizational problem or demand by creating and validating IT artifacts. IT-artifacts in general can be prototypes, models, methods, architectures or other means to solve the identified problem. DSR projects usually need several iterations which search for the best design solution to the problem.

In the case of our research work, the first DSR cycle concerned the development of an innovative digital signage solution for elevator doors which addressed the industrial demand of integrating user interaction and user identification. Fig. 1 illustrates the first DSR cycle which in more detail is described in section III: we started with a problem investigation in the case company (section III.A), developed a solution (III.B), validated and test it (III.C). Within the DSR cycle, different research methods are applied. In our case we started with a qualitative case study for exploring the industrial

demand and problem, and we continued with technical action research.

Qualitative case study [6] is an approach to research that facilitates exploration of a phenomenon within its context using a variety of data sources. This ensures that the subject under consideration is not explored from only one perspective, but rather from a variety of perspectives which allows for multiple facets of the phenomenon to be revealed and understood. Within the case study, we used two different perspectives, which at the same time represent sources of data: we observed the activities during development of the digital signage solution and we interviewed different roles involved in this project.

Most of the work in solution development and validation was technical action research and used the approach by Wieringa and Morali [7]. In technical action research, an innovative artifact or technique is validated and improved by applying it in a real-world setting. The researcher is part of an (industrial) development team and actively contributes to develop a solution or to solve a problem by using the new technique or artifact. At the same time, the researcher collects data and draws lessons learned from the work in the team, which helps to improve. In our case, the new artifact was the design of interaction based on smartwatch and gesture recognition.

The second design cycle is supposed to improve the developed solution. The aim is to better support the situation of several persons waiting for the elevator. The key of this improvement will be the intersecting of user preferences. From Section IV, we tackle the design of this feature, which so far reached the solution development phase only, i.e. this part of our research is work in progress.

III. Industial Case: Elevator Door Signage

As indicated in section II., our work was embedded in an industrial case aiming at the development of innovative digital signage solutions for elevator doors. This section will briefly present the case study company (III.A), show the approach for designing an innovative solution based on gesture recognition and a user identification (III.B), present the actual solution as a result of applying this approach (III.C) and the shortcomings requiring a second design cycle (III.D).

A. Industrial case

The case study company is a developer and manufacturer of elevators and escalators with more than 100 years of tradition, more than 10 billion EURO of annual turnover and global market presence. In this organization with a very traditional “old economy” setting, where IT is applied for optimizing operations, support of administration, development and design of products, and establishment of services accompanying the traditional products, the enterprise started in 2016 to experiment with a new line of business outside the established value chain and support activities. This new business line aims at digital services which use the data communication facilities which are part of each elevator for other purposes than transporting error codes in case of operational problems or sensor information to allow for predictive maintenance.

The first digital service is to offer targeted advertisements on elevator doors. Outside and above the elevator door, a short distance data projector is mounted which projects any kind of information, mostly ads, on the elevator door. As the case study company knows quite well who bought and operates the elevators and what kind of population (i.e., target groups for the ads) is frequently using the elevator, the elevator doors are a promising space for ads and digital signage. Part of the digital service is a content management system for composing the actual content and defining when and where what content should be displayed as part of marketing campaigns.

Fig. 2 shows the principal components of the digital elevator door signage (EDS) solution. The elevator door (1) is cover with a special foil for better visualization of the content. Above the elevator door, a data projector (2) is mounted. The data projector uses the data communication line of the elevator to connect to a central communication device for the elevators in the building (3). This communication device exchanges information by using the cloud with the content management system (CMS) and the elevator operations and maintenance (EOM). The CSM is used for the marketing campaigns and content scheduling; the EOM is out of scope for this paper.

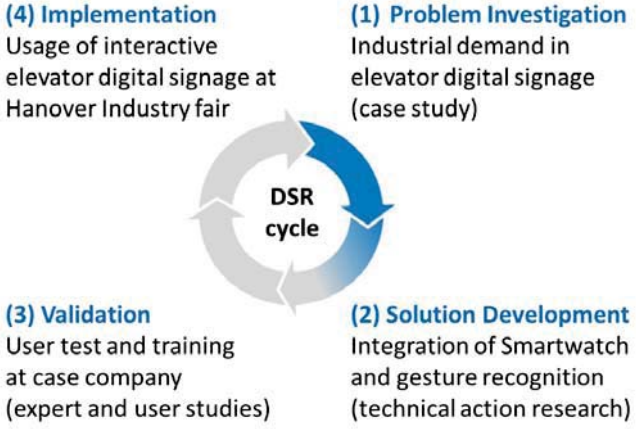

Fig. 1. First Design Science Research (DSR) cycle performed in our work

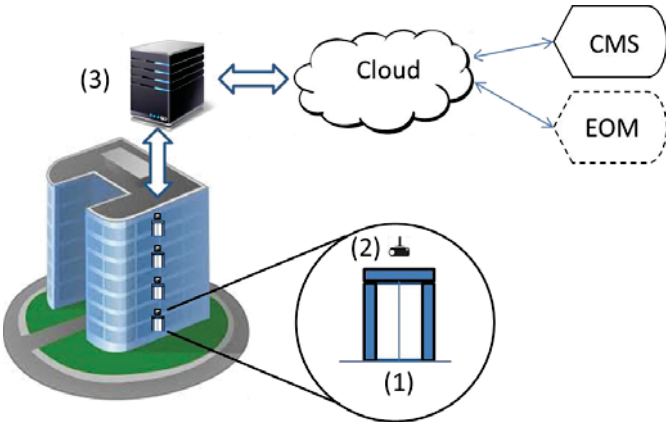

Fig. 2. Components of digital elevator door signage (EDS) solution

B. Approach for digital business model development

In comparison to traditional physical products, the implementation of digital products and digital product innovations has to implement shorter innovation cycles which are more dependent on actual user experience and needs than on long-term product development plans. This requires a tight integration of several dimensions: the desired and achieved user experience with the product/service design, the design of the business model, and the integration into the architecture of the vendor's architecture.

For the extension of the digital EDS solution presented in the above section to an interactive and individualized solution, we used an approach reflecting the above dimensions.

Fig. 3 shows the dimensions of digital business models which guided the development of the digital elevator door signage solution.

The architecture dimension defines how the digital business model is implemented in the enterprise architecture (EA). More concrete, the different architecture layers of EA approaches, such as TOGAF, have to be addressed. These layers concern the technology used for implementing the business model, the applications required and how they interact with other application, the information relevant for implementing the business model and the business processes and organizational roles required. The service design encompasses the actual user interface design, the content model and the performance requirements and specifications for the actual service offered to the user. While the architecture dimension addresses the "macro" level of integration in the enterprise, the service design is directed to the "micro" level of the service for the user. The business model defines the value proposition offered to the customer, the packing of the value proposition into actual services, the distribution, market model and pricing, and the required suppliers and partners. All these dimensions are mutually dependent and aim at an optimal user experience.

C. Digital elevator door signage

In the context of the industrial case introduced in section III.A, the approach described in III.B was applied for an extension of the elevator door signage. This extension aims at adding the possibility of interacting with the content on the elevator door by using gesture recognition and by being able to identify the actual user and his/her preferences using a smartwatch.

In a first design-evaluate cycle, we applied the approach by starting from the user experience we wanted to create, followed by the value proposition for the new business model. The first service design followed which was integrated into the architecture. In the second cycle, the service design was improved and validated against the desired user experiences before refining the business model and designing the required organizational processes in the architecture.

Table I shows potential emotions linked to the user experiences of interactive content and content without interaction on the elevator door. The user experience of the digital signage was targeted at creating the positive emotions identified and avoiding the negative ones. The comparison between interactive and non-interactive content shows that interactive content has significant advantages over non-interactive one.

Table II shows the value proposition attributed to the digital signage solution, which has to be divided into value for the end user (i.e., the persons waiting for elevators) and value for the client (i.e., the customers of the use case company installing the digital signage for their elevators).

With respect to the technology architecture, the following requirements were identified which at the same time formed the fundament for service design and were affected by this design:

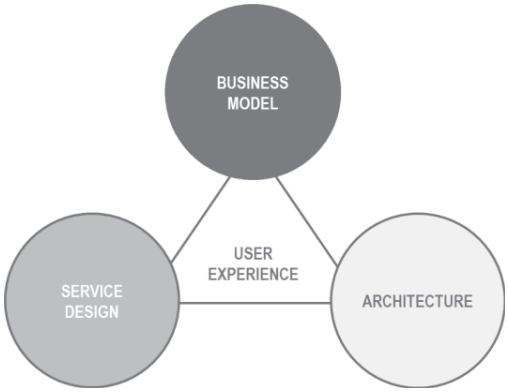

Fig. 3. Dimensions of Digital Business Models and Solutions

TABLE I. EMOTIONS LINKED TO USER EXPERIENCE OF THE ELEVATOR DOOR SIGNAGE

Content Type / Potential UX	Content w/o interaction	Interactive Content
Positive experiences	Attraction, fun, interest	Being in command, "my content", fun, attraction, interest
Negative experiences	Boredom, disinterest	Boredom, disinterest, frustration (if functionality does not work)

TABLE II. VALUE PROPOSITIONS RELATED TO THE ELEVATOR DOOR SIGNAGE

	Value proposition
End user	Relevant content (advertisement or information) for the location; Entertainment for more pleasant waiting time; Special deals linked to digital signage
Client owning the elevator	(a) communication channel to end user: capture attention of the user for advertisement and content presented; (b) support of innovative and modern image; (c) based on (a): new source of income or re-financing elevator's operation costs

- display of content with adjustment to all door types
- time and location-based scheduling
- remote control and maintenance
- smartwatch communication via ultrasound
- gesture recognition for area in front of elevator

The business model is manifested in the business agreements currently offered to the operators / owners of the elevators. Current types of agreements are (a) to buy the digital service for a defined rate and receive the revenue from selling ads, (b) to combine the digital service with conventional elevator maintenance service and reduce the maintenance fees in exchange for selling ad space on the doors, and (c) to buy the service infrastructure (projects, content management system) and run the digital service in own responsibility. More advanced business models are under development but will have to take into account experiences from operations.

Based on the above considerations of user experience, value creation and business model, a solution was built implementing the required features of the technology architecture. Fig. 4 shows the first working prototype of this solution mounted on a mock-up (wooden) elevator door. The solution version presented on Hanover Industry Fair in April 2017 also included a new case design for the data projector which included the gesture recognition device in the case.

Before the solution was presented in Hanover, various test and evaluate cycles were performed which started with test users from the university context and continued with field tests at the case study company.

D. Limitations for multiple users

User experience, value creation and business model clearly show the importance of personalized context and individual preferences when offering innovative digital signage solutions. The user experience and, as a consequence, the value offering is considerably lower when more than one individual waits in front of the elevator. – Which individual should be the one in control of the content? Different strategies could be applied, like, e.g., who arrives first will get the control for the remaining waiting time; if many persons arrive at the same time a common denominator of the interests of all persons is determined; the most important customer or person from the operator's point of view overrules all the other persons; the majority decides about the content; etc.

More work is needed on this topic which resulted, in a first step, in our work on intersecting preferences described in the next sections. The solution implemented in the case is that the one person closest to the center of the elevator door and starting to interact by raising his hand gets the control. All other person only can watch the content. For the demonstration at Hanover Industry Fair, this was an excellent solution as it created a small queue of people curious to try the gesture recognition and created attention for the solution. However, if this approach is the best one for all application situation needs to be investigated.

Fig. 4. Prototype of interactive EDS solution on mock-up elevator door

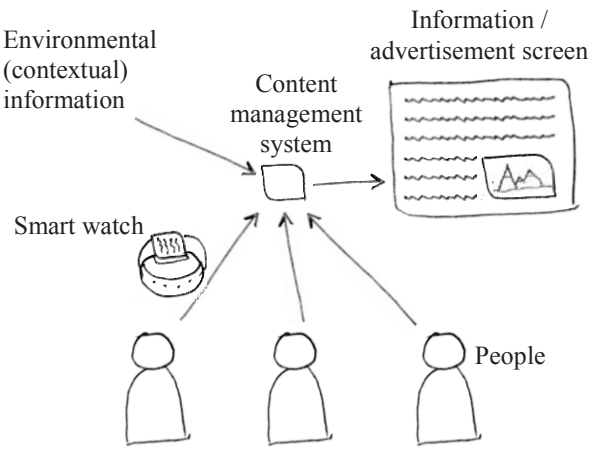

Fig. 5. Information flows for targeted digital signage

IV. Proposed improvement (Targeted Advertisment)

As it was described, the current product can indicate either common information or information related to a particular person. However at the places where several people can gather indicating personal information is not possible due to confidentiality restrictions. However, certain generalization of interests and preferences of a group of people can be possible for increasing the efficiency of such advertisements.

We propose the following improvements (Fig. 5). The information about people is acquired by the content management system. The users are identified through some personal electronic devices (smart watch in the considered case). Here, there can be two approaches:

- the information (preferences / interests) is stored in the personal information device;
- the information is stored in the cloud and personal information device serves only for identification of its owner.

The first approach can be efficient in places where there can be different people, who are not related with each other (e.g., shopping malls, public transport, etc.). The second approach would be more efficient for e.g., information screens in companies, where the possible audience is limited by a certain society (company's employees). However, the second approach is also applicable when the advertisement is provided by a large provider (e.g., Google), which have their own database of users with their interests and preferences.

These approaches are different from the technical point of view, but within the scope of the paper there is no difference for preference grouping if they are acquired from a device or from a cloud. Therefore, we will not concentrate on the implementation specifics.

The content management system performs the analysis of the preferences and interests of the people nearby and identifies the most appropriate topics or information pieces based on the generalization of the preferences and interests. The resulting personalized information is displayed on the screen.

V. PREFERENCES

In order to define which preferences / interests can be used in which context it was decided to use knowledge forms proposed by Wiig [8]: Public, Shared, Personal.

Wiig gives the following definitions to the forms [8]:

1) Public Knowledge – The most accessible knowledge is predominantly explicit, taught and shared routinely, and generally available in the public domain. Public knowledge is primarily systematic although some is idealistic and pragmatic.

2) Shared Expertise – The proprietary knowledge assets is exclusive knowledge held either by knowledge workers and shared in their work, or embedded in technology and other proprietary manifestations. It may be explicit albeit then often communicated by specialized languages or representations. Shared expertise is primarily pragmatic knowledge although this type of knowledge also includes idealistic and systematic knowledge, and experts may refer to automatic knowledge.

3) Personal Knowledge - The least accessible and most complete knowledge - exists tacitly in people's minds and is used non-consciously in work, play, and daily life. Personal knowledge consists for a small part of automatic knowledge. The majority of personal knowledge, however, consists of idealistic, systematic, and even pragmatic knowledge that is not explicated or clearly understood.

Speaking of advertisement and related to the problem at hand the knowledge forms can be interpreted as follows:

1) Public knowledge is "known" to everyone (commonly known facts). Usually, it is the context of the current situation (weather, date / time, other public information). It can be used for contextual advertising without any restrictions.

2) Shared knowledge is limited within a community (e.g., a company, department, family). It can be used for advertisement targeting when only members of the same community can see it (e.g., meeting announcement within a department).

3) Personal knowledge to a person only. Generally, it cannot be used for any public advertisements.

Below, these are considered in detail.

A. Usage of public information

As it was already mentioned, public (environmental, contextual) information can be freely used for contextual advertisement. E.g., advertising soccer souvenirs before a championship. However, this cannot be referred to as "targeting".

B. Usage of shared information

Since shared information is limited within a community, it can be distributed within the same community. The most obvious example is a company's or department's building and the digital signage can be done through a screen in an elevator, hall, etc. An example of such information can be an upcoming meetings with their times and locations, exhibitions, success stories or new software tools.

C. Usage of personal information

As it was already mentioned, generally, the personal information cannot be used for any public advertisements. However, in certain conditions, when this information is not marked by a person as private and cannot compromise him/her, it still can be used for targeting. For example, if people in the elevator of a shopping mall are interested in buying a dishwasher machine (they did a search through their mobile devices) the appropriate advertisement can be shown. However, one has to be very careful with choosing which information can be considered as potentially compromising and which is not. Besides, making people to mark which of their preferences / interests are private and which are not can be a challenging task. This is a topic of further research.

VI. INTERSECTION OF PREFERENCES

Intersecting preferences of various users is not an easy task. The closest area of research is the group recommendation

systems based on the methods of collaborative filtering or similar. These methods are aimed at identifying groups of users with similar interests and preferences. In other words, they solve the problem opposite to the one set in the paper. Nevertheless, some techniques still can be applied within the frames of the research.

First of all, there are not so many works aimed at profile structuring so that it can be easily processed in an automatic way. Having carried out an analysis of the related works the authors of [9] state that their "work is one of the starting points for preference profiles which are ''close'' to being nicely structured".

The authors of [10] use quantitative preference estimations for hierarchically organized preferences (with associative relationships like "the author of", "the genre of", etc.). This is an efficient preference organization when only one domain is considered (e.g., movies). However, when the domain is wide and not well defined such model will not work.

Application of ontologies for preference description can be considered as one of the most efficient solutions to this problem.

Ontology is an "explicit specification of a conceptualization," which is, in turn, "the objects, concepts, and other entities that are presumed to exist in some area of interest and the relationships that hold among them" [11]. Ontologies have proven themselves as and efficient instrument for structuring knowledge about a problem domain [12]. The same applies to the organization and structuring of preferences.

In [13] unique ontologies are used for every domain. The ontologies are described in OWL. The preferences are quantitative and assigned to various ontology nodes. The hierarchical organization of the ontologies makes it possible to generalize the preferences though this opportunity is not reflected in [13].

The organization and description of preferences with the use of ontology is considered to be efficient in the current research as well.

Another issue is collecting the preferences. It is not so easy to make people to manually set the preferences in an application or a web-page. As a result, this process has to be automated. The authors of [14] track long-term user behavior with the help of software agents to construct the ontology-based profiles of users.

Another possibility is preference grokking [15] by crowd workers. Sometimes this can be an efficient approach, especially to solve the "cold start" problem of personalized systems. However, requirement to have a crowd available can put some significant constraints on its applications.

The designed framework for preferences / interests organization is based on the "is-a" relationship (fig. 6). That makes it possible to easily switch from detailed preferences or interests (e.g. Architecture of XVII century) to more general ones (e.g., Architecture). The nodes do not necessary have only one parent but could have several ones (the relationship is "many to many"). Such representation is aimed at the problem of preference heterogeneity. If we randomly pick several people the probability of them to have same preferences is low. So, the preferences are generalized and in this case the match of preferences is higher. The delivered information (advertisements or other information) is also tagged with the nodes of the same structure.

The information processing unit picks up the information that is tagged by the node that is the parent for all or most nodes representing the preferences / interests of the people considered (Fig. 7). In the figure the preferences are indicated as bold circles, and the resulting node as black circle.

VII. Related work

A. Preference and information demand modeling

How to capture the preferences of users has been subject of research in various fields, for example in information logistics. This section will briefly introduce three approaches for this purpose: user profiles, situation-based and context-based demand models.

User profiles have been subject to research in information systems and computer science since more than 30 years. User profiles are usually designed for functionality provided by specific applications. Profiles are based on a predefined structured set of personalization attributes with assigned default values at creation time. Adaptation of such profiles requires either deducing attribute values through recording and interpreting of user actions, or involves an explicit adjustment of the preference values by the user [16]. Some approaches aim at a generalization of user profiles for complete application domains with the objective to enable different

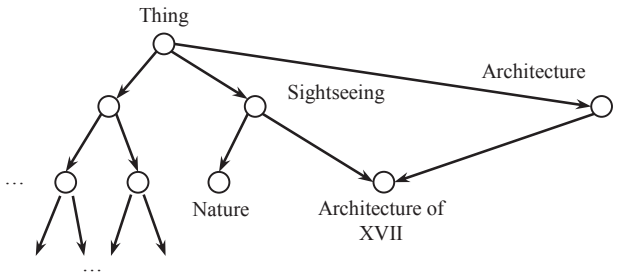

Fig. 6. Organization of preferences / interests

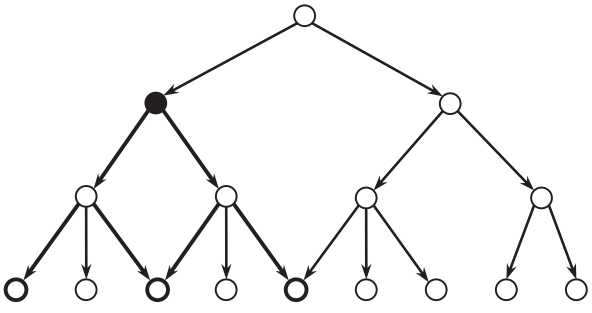

Fig. 7. Intersection of preferences / interests

services to use the same profile for adapting appearance, behavior or data sharing. A frequently discussed approach is the W3Cs standardization activity for Composite Capabilities and Preference Profiles and Device Independence (CC/PP) [17]. Instead of a fixed set of attributes, CC/PP aims at extensible structures for profiles based on a common predefined vocabulary and a set of rules.

Applying user profiles for representing information demand requires a relatively large set of attributes, as the profile should cover all dimensions relevant for context-based information supply, like, e.g., content, time, location or quality. Experiences from projects in information logistics indicate that user profiles are suitable when the information demand is quite stable [18].

For the application area of demand-oriented message supply, a situation-based approach was proposed in [19]. The basic idea is to divide the daily schedule of a person into situations and to determine the optimal situation for delivering a specific message. This approach defines situation as an activity in a specific time interval including topics and location relevant for the activity. Situation-based description of information demand allows for a more sophisticated capturing of user demands as compared to user profiles. The situation captures aspects of individual information demand in a more dynamic way than user profiles. The approach also includes calculation of the information value which adds further dimensions, like acceptance, and offers a way of deciding on when to supply information. However, this approach is subject to the same criticisms as user profiles: the task of defining situations and topics is requiring considerable efforts and has the danger of getting inaccurate and outdated over time.

A context-based approach was proposed for use in enterprises, public authorities or networked organizations. The basic idea is that information demand of a person in an enterprise to a large extent depends on the business processes this person is involved in, on the co-workers or colleagues of this person and on the products, services or resources the person is responsible for. This led to the proposal [20] to capture the context of information demand, i.e. a formalized representation of the setting in which information demand exists, including the organizational role of the person under consideration, work activities, resources and informal information exchange channels available.

The development of a context model could be performed in different ways, such as interviews with different persons in different roles within an organization, task or information flow analysis, or process modelling. Thus, this approach would only be suitable in an organizational use of digital signage.

B. Digital business models

Business models have been an essential element of economic behavior since decades, but received a significant increase in attention in research with the advent of the Internet [21] and the expansion of industries dependent on post-industrial technologies [22]. In general, an enterprise's business model describes the essential elements that generate and deliver a value proposition for the clients or customers, including the economic model and underlying logic, the key resources and key processes. Digital business models concern products and services which massively are based on mobile technologies, the integration of sensor information, digitized operational processes or completely digital products.

Zott and Amit identified three major lines of work in their analysis of recent academic work in business model developments [23]:

- Business models for e-business scenarios and the use of IT in organizations
- The strategic role of business models in competitive advantage, value creation and organizational performance
- Business models in innovation and technology management.

For designing innovative digital business models we consider both value creation based business models for the service industry and approaches from e-business as promising [24], [25]. For the purpose of the approach presented in section III.B, the proposal by Wirtz seems to be most suitable due to the explicit identification of six partial models: capital model, procurement model, manufacturing model, market model, service offer model, and distribution model. In this way the essential parts of value creation are covered.

The capital model is subdivided into financing model and revenue model. The financing model describes the sources of the capital that is necessary for business activity. The revenue model provides means to generally systemize business models by four dimensions: direct or indirect generation of revenue, as well as the transaction-dependent and the transaction-independent generation of revenue. The procurement model describes production factors and their sources. Here the distribution of power between suppliers and demanders is an important aspect. The manufacturing model covers the combination of input factors to new goods and services. Demand structures as well as the competitive situation are described by the respective sub-models of the market model. The service offer model defines which IT services are provided to the customers, while the distribution model focuses on the channels that are used to make the IT services available to the specific customer groups. Wirtz has proposed a categorization of e-business models by the kind of IT service offered (see figure 8).

VIII. SUMMAY AND FUTURE WORK

This paper focuses on the field of digital signage and approaches on tailoring the content for the preferences of the audience. Specific focus is on elevator digital signage solutions. The paper investigates business model development in this field and proposes an approach for intersecting user preferences. The research method used is design science research. The intended contributions of the paper are an industrial case of digital business model innovation not discussed in research before which motivates contextual digital signage, the approach for intersecting personal preferences, and the draft of a method for digital business model innovation.

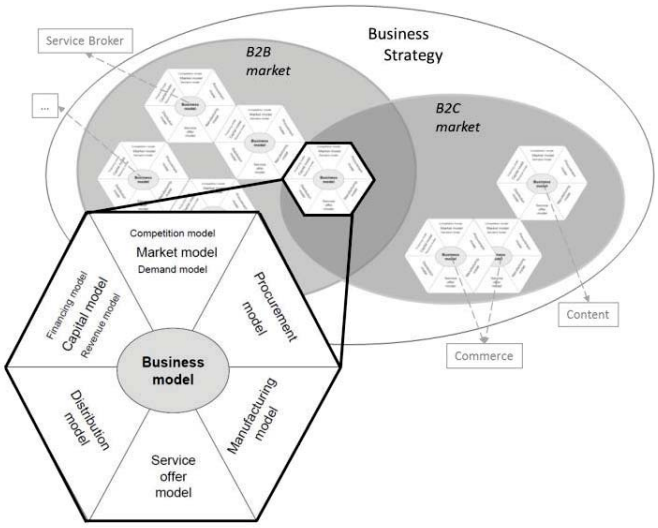

Fig. 8. Partial models of the integrated business model [25]

Future work will have to focus on technical and method aspects. The ideal digital signage solution would be able to provide individualized content for the audience consuming the information at any time: if only one person is present, the content would be personalized for this person, if a group of persons is present the demand of all should be met. This would require continuous recognition and identification of the current audience for the digital signage, their preferences and the matching content, which requires more work in developing our approach for intersecting preferences and integration with content aggregation, filtering and matching as well as user identification and profiling techniques.

From method perspective, the technical work described above will contribute to completing the ongoing second DSR cycle and probably motivate more cycles. Furthermore, the business model development approach presented in section III needs further elaboration and application in more cases.

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