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A Conceptual Framework for Backend Services of Contextual Digital Signage

Christine Bauer, Paul Dohmen, and Christine Strauss

ABSTRACT

Digital signage is a rapidly emerging marketing channel that promises to reach out to consumers at any time and any place. Still, it is a rather novel research field. First empirical studies focused on consumer behavior. At the backend, though, digital signage brings together various market players, all of which with their very own business objectives and expected benefits, where some of which may complement one another and some might be conflicting. In order to tap the full potential of digital signage, the entire range of market players need to be provided with appropriate backend services. In emerging, technology-driven applications such as digital signage there is a vital need for a universally valid, flexible, structuring framework that provides the basis for target-oriented research using a shared conceptualization. In fact, such a framework is essential to enable, yield and foster

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sustainability in a novel and interdisciplinary research field like digital signage. For this reason, we introduce a cohesive and flexible conceptual framework for contextual digital signage that integrates the entire set of possible market players in their relevant roles, application location categories, strategies and contextualization types of a contextual digital signage system.

KEYWORDS

Digital signage, Contextual digital signage, Contextual advertising, Public displays, Framework.

1. INTRODUCTION

'Digital Signage' – frequently coined as 'Digital out-of-home advertising' – is a rapidly emerging marketing channel that promises to leverage digital screens to reach out to consumers electronically, to influence purchase decisions efficiently in the right moment and in the right place. Digital signage is said to be "poised to disrupt a major component of the advertising industry" (Harrison, Andrusiewicz 2004). It contributed with revenues of about 5 billion USD to the global economy in 2012, and the digital signage market has been projected to triple by 2016 (Want, Schillit 2012).

However, although advertisement investments have increased, advertising effectiveness has suffered dramatically in recent years. As consumers have been overloaded with promotional messages, attracting the consumers' attention has become an increasingly challenging task (Pieters et al. 2002). As a result, marketing researchers seek new ways and novel services to increase advertising's effectiveness.

Digital signage is a promising medium to prevail over the information clutter because electronic displays used for digital signage provide new opportunities and advantages over traditional 'static' signage. For instance, it allows displaying dynamic presentations containing audio, video, and animations (Harrison, Andrusiewicz 2004). Additionally, signs point to the dormant power of contextualization, where sensors and other technologies are used to recognize the situational context in real-time and to display matching content (Müller et al. 2009a; Bauer, Spiekermann 2011). Digital signs using such features are a realization of contextual digital signage (Satoh 2010; Müller et al. 2009a; Carreras et al. 2010): the system selects and displays advertisements based on contextual triggers such as time, location, weather, characteristics of beholders, etc. (Lee, Lee 2007; Görlitz, Schmidt 2008). We define contextual digital signage as *displaying an advertisement that is relevant to an individual or to a group of individuals in the present situation based on information about the current situation, which is retrieved, transformed, and/or deduced from any information sources*. Accordingly, it allows for realizing locally relevant advertising concepts that catch people's attention. For instance, Silberer (2010) indicates that the advertising effects of digital signage largely depend on the display's environment. This result is confirmed by Telschow &

Loose (2008), who state that advertisements directly related to the current purchasing situation are remembered better by consumers than unrelated advertisements.

However, beyond the frontend service "advertising" that is directed to the consumer, (contextual) digital signage brings together various market players on the backend. These players are guided by their very own objectives and expected benefits (cf. Bauer et al. 2011), which may complement each other or may be conflicting. Yet, taking a holistic perspective integrating the entire set of relevant market players and their required backend services for (contextual) digital signage has not yet been considered in this research field's early approaches.

As it is a new research field and a technology-driven application, though, a framework is essential in order to allow for sustainability, both in research and in practice. To avoid undesirable effects (e.g., considering only selected market players under different assumptions, bias through emphasis on selected aspects, etc.) that inhibit the development of an integrated, cohesive approach, a framework provides a guideline for researchers and further allows for sustainability in the entire research thread. As a consequence, a framework also impacts sustainability on the digital signage market itself, as a homogeneous basis supports transparent research results, that will be more likely consulted by decision-makers and provide them with scenario-based implications.

For this reason, we develop a cohesive and flexible conceptual framework (Embley, Thalheim 2011) that identifies (1) relevant market players and their roles and (2) potential modules for contextual digital signage systems such as application location categories, strategies and contextualization types. In doing so, we provide a basis for a holistic, integrated approach that allows for further (interdisciplinary) research. For industrial applications the conceptual framework supports platform providers on a strategic level when implementing such a system.

The remainder of this paper is structured as follows: the article provides an introductory overview of digital signage by presenting the media format and discussing its impacts. The core section thereafter expounds the conceptual framework for contextual digital signage by identifying relevant market players and their roles, application location categories, strategies, and contextualization types. For illustration, we discuss an exemplary scenario applying the

proposed framework in the section thereafter. We finally conclude with a summary and recommendations for future research.

2. DIGITAL SIGNAGE AND ITS ECONOMICS

2.1 The Media Format 'Digital Signage'

A myriad of descriptors have been used to term networks of displays in public space. When such displays are used for advertising purposes, the frequently used term is 'digital signage' (e.g., Telschow, Loose 2008; Müller, Krüger 2007a; Burke 2009). However, the term 'digital signage' is also often used in literature for referring to any kind of shop TV, stand-alone plasma or LCD screens in stores. However, digital signage is a networked, audiovisual information system that allows remote controlling contents – either program-driven or manually – but in any case from a centralized system. It consists of several decentralized digital displays interconnected with a central system consisting of a content management system and a user rights management system (NEC Display Solutions 2006; Goldberg 2007; Russell 2009).

Literature on the phenomenon of digital signage and particularly research exploring the effects of contextual digital signage is limited. Only a few academic (e.g., Burke 2006, 2009; Dennis et al. 2010a; Dennis et al. 2010b) and commercial (e.g., NEC Display Solutions 2006; Porter 2012) studies investigate the effects that digital signage has on consumer behavior. Thereby studies zoom in on atmospherics (Dennis et al. 2010b), content (Loock et al. 2010), interaction features (Chen et al. 2009; Cardoso, José 2009), or consumer reactions (Burke 2009). Still, from a scientific viewpoint, research on digital signage is insufficient by now. First, there are no experiments that compare digital signage to traditional means of advertising concerning their effects. The majority of studies argue on a very shallow and imprecise level. For instance, retailers such as the British supermarket chain Tesco or Spar in Germany report that using DOOHA at the point of sale increased sales by 25-60 percent (NEC Display Solutions 2006; Porter 2012) without indicating any reasons for the observed sales increase. Furthermore, studies typically take an advertiser's perspective, investigating which effects digital signage and its contents or activity levels have on consumer behavior.

2.2 Benefits of Digital Signage

Traditional paper signage is characterized by a slow and expensive CDI cycle (creation, distribution, installation): not only does this cycle encompass days or weeks, it is also expensive due to labour and material intensity (Harrison, Andrusiewicz 2004). Digital signage, in contrast, is able to virtually eliminate the costs of the distribution and installation components within this operational cycle. Printing costs are completely eliminated; assuming 5 posters per week and 52 weeks per year demonstrates a cost saving of more than 5,000 USD per year per store (Scala 2012). Still, the implementation of a digital signage system requires rather high initial investment; thereafter contents can, though, be changed automatically from a remote system at relatively low cost.

While static images are only able to display one message to the audience, digital signs can change contents within milliseconds and can hence present various advertising messages according to a schedule.

Additionally, the increased effectiveness of digital signage provides an opportunity for sellers of display time (so called 'time slots') to increase the price of slots for which there is more demand. Since human attention to advertising space is a scarce resource, auction mechanisms are often used to maximize the seller's utility (Müller, Krüger 2007b; Payne et al. 2006). The possibility to engage in such price discrimination appears in conjunction with the increased effectiveness that is disposable for the advertiser and the technical ability to easily change contents via remote control. Hence, the achieved cost reductions due to lower expenses in the CDI cycle might partly be offset by this opposing opportunity for the seller.

2.3 Added Value of Contextualization

One could assume that so called bottom-up effects such as displays size, height of installation or the angle of a display to the walking direction may strongly affect consumers' perception. Although it cannot be denied that these factors influence whether consumers look at a digital sign, the top-down effects have shown to be more important: "Whether users expect interesting content seems to be more important than other effects that could be naively assumed, like the display size" (Müller et al. 2009b). In other words: providing relevant

content is the key for sustainable advertising effects (Müller, Krüger 2007b). For instance, on the Web, prominent, interruptive pop-ups are less effective than contextual keyword advertising (Acquisti, Spiekermann 2011). Contextual keyword advertising consists of advertisements that are related to search keywords and appear next to search results (e.g., market leader Google's AdWords (Google 2012)).

Research in psychology and marketing has long acknowledged the influence that the current situation has on the human processing of information. An entire research thread in psychology (environmental psychology) is dedicated to the effects that surroundings have on human perception and behavior (Chapter 3 of Bechtel, Churchman 2002; Mehrabian, Russell 1974).

On the Web (e.g., Linden et al. 2003; Adomavicius et al. 2005; Smith 2004) and in the mobile domain (e.g., Yuan, Tsao 2003), adaptation mechanisms already make use of contextual information to adapt advertisements, search results or recommendations to the particular situational context of users such as weather, daytime, etc. In short, it is common understanding that the current context influences the perception and processing of advertisements, which implies that adapting an advertisement to the current context may achieve very different and positive advertising effects.

Equipped with respective 'context capturing' technologies, also digital signs can adapt advertisements (i.e. content) instantly to fit any measurable context (Müller et al. 2009a). Adjusting advertisements to the current context offers the potential to create relevance for the consumer (Telschow, Loose 2008), which in turn increases the probability of passersby's attention and thus advertising effectiveness. For instance, Silberer (2010) indicates that the effects of advertisements largely depend on the digital sign's environment. This result is confirmed by Telschow and Loose (2008), who state that advertisements that are directly related to the current purchasing situation are better remembered.

In essence, context-drivenness implies that the advertisements are better targeted to the consumers as well as their current situations and aims. Hence, the advertisements have a higher probability of being relevant and, thus, they gain more attention (Müller, Krüger 2007b).

2.4 Behavioral Effects of Digital Signage

Digital signage is able to fulfill a dual usage in retail environments like shopping malls (Dennis et al. 2010b): On the one hand, it can convey relevant information to consumers such as for example store-specific offers. On the other hand, digital signage acts as an important effective atmospheric stimulus, "adding to positive perceptions of the mall environment, emotions and approach behavior such as spending" (Dennis et al. 2010a; Dennis et al. 2010b).

Recent research emphasizes that interaction possibilities in digital signage systems are able to increase consumer value, by raising consumer engagement (Cardoso, José 2009) or emotional perception (Exeler et al. 2009). Exemplary interaction capabilities are (1) presence, where displays are able to identify information about the audience, (2) self-exposure, where displays are able to adapt their information on the basis of the audience's interests, preferences or activities, or (3) actionables, where consumer reactions are captured (Cardoso, José 2009). While beholders keep passive in (1) and (2), consumers might engage actively (either intentionally or implicitly) in a certain behavior (e.g., raising an arm, touching the screen) in version (3). Advancement of information technologies (e.g., Radio-Frequency Identification, Bluetooth, gesture-sensing technologies) and the increased adoption of technological devices (e.g., Smart Phones) make interaction an attractive option for increasing consumer engagement.

3. A CONCEPTUAL FRAMEWORK FOR BACKEND SERVICES OF CONTEXTUAL DIGITAL SIGNAGE

In the following we provide a conceptual framework, which may form the basis for researchers and developers to tailor advertising in public space to the needs and requirements of the respective audience. For research and development the framework provides the objectives of relevant market players and core modules of a digital signage system; for industrial applications it supports platform providers and decision makers on a strategic level when implementing a digital signage system.

Developing such a framework is an inherently iterative search and design process that follows a set of continuous cycles of generating and evaluating design alternatives. We have

chosen the *informed argument method* (Hevner et al. 2004) to design the proposed framework by applying this method iteratively throughout the design process. In an initial phase we tapped the knowledge base of our research domain and critically reflected recent literature during analytical group reflection sessions; a framework's draft version was stepwise improved by applying the *informed argument method* and generating enhanced alternatives. Group reflection phases *after* each generate/evaluation cycle helped to converge different design alternatives into one coherent framework. Each cycle contributed to the advancement of the framework leading to the final one as presented in the remainder of this section. The approach of generating and evaluating our proposed conceptual framework for backend services of contextual digital signage is visualized in Fig. 1.

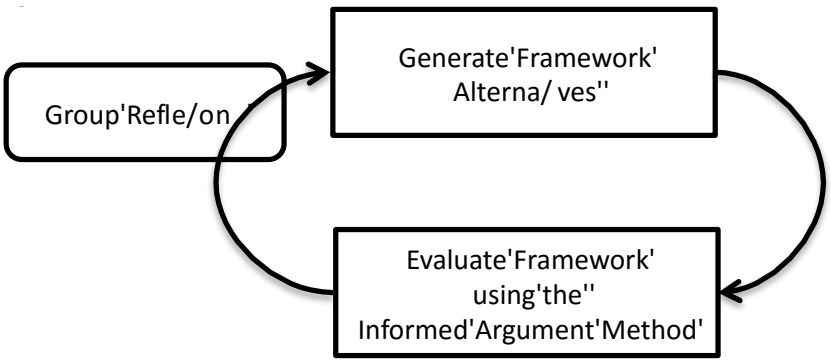

Figure 1. The Generate/Evaluate Lifecycle using the "Informed Argument Method"

Fig. 2 contains a synopsis of the market players and their roles, application location categories, strategies, and contextualization types that are important when setting up an efficient system. It provides a graphic overview of our framework highlighting those elements that will be described in the following subsections. Note, that we present a conceptual framework that addresses digital signage on a strategic level, indicating what services digital signage providers need to consider in the backend. This paper does not suggest system architectures on a technical level (as for example in: Maeda et al. 2010; Simoes et al. 2009; Sun et al. 2010).

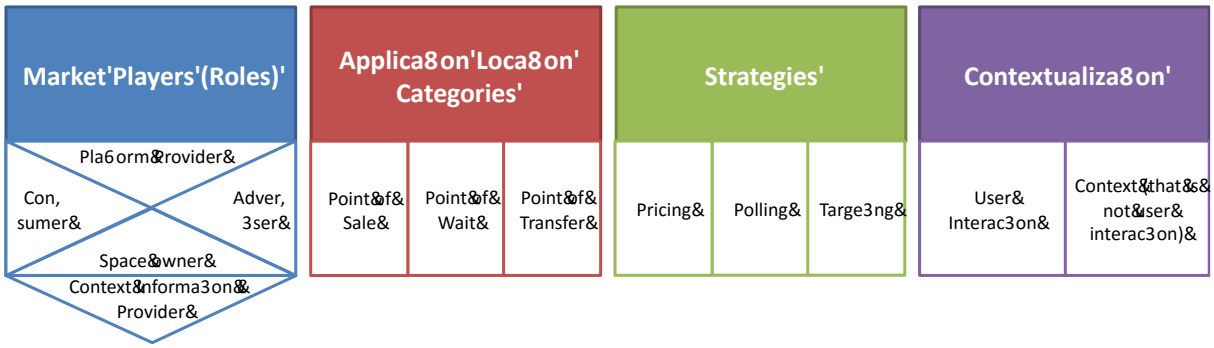

Figure 2. Major roles, application location categories, strategies and contextualization types of a contextual digital signage system

3.1 Market Players

Before setting up a digital signage system it is important to understand the potential market players and their roles involved in the system (Kelsen 2010). The system integrates at least three major market players, depending whether platform, space and context information is provided by the same or distinct entities: similarly to classic marketing forms, the *advertiser* wants to see his product or service marketed, as well as a *consumer*, to be appealed by the advertisement. A *platform provider* offers the infrastructure (hardware, network), software (algorithms), user rights management and content management for the digital signage network.

Usually, a fourth and/or fifth market player is included with a digital signage system. A *space owner*, typically not the platform provider, owns the space where the displays are installed. When adopting *contextual* digital signage, the role of a *context information provider* needs to be considered. This market player offers information about various kinds of context such as weather data, information about consumer profiles passing by the display, or sociocultural information, which applies for the particular location of the display. On the one hand, the platform provider may include, for instance, sensors in the digital signage system for sensing context such as the audience's attention or emotions (Exeler et al. 2009). On the other hand, contextual information may come from a third party who grants access to context information such as weather data or socioeconomic information for a certain region in exchange for a license fee.

3.2 Application Location Categories

We distinguish three types of locations where digital signage may be applied: point of sale (POS), point of wait (POW) and point of transit (POT) (cf. Kelsen 2010).

- The *point of sale* (POS) is currently the largest application area for digital signage. Examples of digital signage at the POS are gas stations and convenience stores, shops with consumer goods, home improvement/household utility stores. Since 76% of purchase decisions are taken at the POS (POPAI 2012), it becomes obvious that advertising within retailers' business premises is important for marketing success.
- At the *point of wait* (POW), consumers wait for a certain product or service, for example in a queue at the doctor or in an elevator. Exemplary applications are healthcare, retail banking or office buildings. Longer waiting times at the POW enable advertisers to show longer messages and more repetitions. Typically, consumers are more deeply involved with the content shown, and the advertising benefits might be more long-term oriented.
- The third alternative is the *point of transit* (POT), where the audience (in transit) passes a signage. This kind of signage is typically found at airports, metro, train or bus stations, and store windows. The function of displays in this location is to catch passersby's attention in a very short time period. Since advertisers are at maximum able to create a thought-provoking impression, the content has to be well evaluated. Instead of advertising particular offers, digital signage at the POT is therefore used to establish brand identity and increase brand value successfully.

This threefold categorization provides a systematic identification of application location categories on a high abstract level. The next level contains descriptions of these levels in more detail, by considering a specific location category within a certain level, e.g., a supermarket at the POS, a doctor's practice at the POW, or a platform at a train station of the POT. On the most detailed level of abstraction concrete installations within one of the described application location categories are considered: e.g., Big John's corner shop in New

York Fifth Avenue, the waiting room of Dr. Jane Doe's medical practice, or the metro station in London Oxford Circus.

3.3 Strategies

Having the information about the market players (roles) and having become clear about the application location categories, a platform provider may start determining which adaptation strategy will be followed. While existing literature argues that the central system of digital signage consists of a content management system (NEC Display Solutions 2006; Goldberg 2007) and user rights management (Goldberg 2007), we add as a third component a the strategies to be followed. The strategy component consists of three main decisions for services: the selection of the *pricing mechanism*, *polling mechanism* and specifying the advertising *target*.

- Central question for determining a *pricing mechanism* is how display time (so called 'time slots') is 'sold' to advertisers. Interactive pricing mechanisms (cf. Schwind et al. 2008) for 'time slots' allow price adaptation according to demand fluctuations. Since human attention to advertising space may be interpreted as a scarce resource, auction mechanisms are a viable alternative to maximize the seller's utility (Payne et al. 2006). In an English auction, for instance, the highest bid receives the advertising slot for the specified bid price. On the Web, such auctioning mechanisms are currently successfully applied for contextual advertising such as Google AdWords. Alternatively, one can attribute the time slots to content, for example, per supplier or per location. In this case, the provider would follow a fixed-price strategy. A combination is also possible, for example where an auctioning mechanism is used for a predetermined location or for a predetermined time frame.
- A *polling mechanism* is required in order to select and retrieve a certain advertisement. A variety of criteria is at disposal: one may, for instance, show the most demanded advertisement. Alternatively one may choose the contextually most appropriate content, the latest advertisement added (i.e., the newest content), etc. Furthermore, one may apply an auction mechanism for both pricing and polling. This

means, the advertisement of the highest bidder (English auction) would be shown (for the price of the highest bid).

- Before being able to set up rules concerning which advertisements should be shown, it is necessary to determine the advertising's target (*targeting*). On the one hand, one may optimize toward a maximum number of people paying attention, although the attention of these beholders may or may not translate into purchases of the advertised product. On the other hand, one may attract fewer people, but in this case the 'right' ones who will finally buy the product.

Contextual advertising exhibits some similar characteristics like keyword advertising on the Web (prominently used by search engines): it provides advertisers with the service to show those advertisements that are most likely relevant to the consumer in that moment (Naldi et al. 2010). This is also promising for contextual digital signage. As there are usually fewer time slots than (potential) advertisers, slots become a scarce resource. For contextual advertising, auctions are currently considered to be the promising market mechanism, both as pricing as well as polling mechanisms (Müller, Krüger 2007b; Payne et al. 2006). The main challenge is to auction the time slots efficiently (Payne et al. 2006). However, in situations where context-aware query processing is not used, information for relevance estimation must be gathered in an alternative way. For instance, interactive signage provides the possibility that consumers interact actively with the displays (Leikas et al. 2006; Chen et al. 2009; Kuhlman 2009), so that the interaction process may determine relevant content. A further mechanism is to have consumers accept to be opted in via technologies such as Radio-Frequency Identification (RFID) (Payne et al. 2006; Cardoso, José 2009; Satoh 2010), so that personal context information such as a user profile may be used to select those ads which are the best match. Relevance may also be obtained via 'non-personal' context information such as weather data; for instance, showing an ad for skiing when it snows or providing information on clubs and bars nearby after a concert, etc.

3.3 Contextualization

Adapting displayed information based on contextual factors that relate to the environment (e.g., location, time, activities, or people) is an emerging service capability of digital signage applications (Lee, Lee 2007; Carreras et al. 2010). Although such applications still face tremendous challenges with respect to how contextual information can be optimally derived or how contextual information from different sources may be combined efficiently (Carreras et al. 2010), digital signage systems are increasingly equipped with the functionality to retrieve and use contextual information (e.g., light sensors, cameras, microphones, RFID scanners, etc.).

Being equipped with such sensors and hardware allows digital signage to interact with users. Thereby interaction modalities could be based on, for instance, facial expressions (Küblbeck, Ernst 2006), eye gaze (Müller et al. 2009a), or body postures (Vogel, Balakrishnan 2004). A distinction can be made between contextualization through *user interaction* and through adaptation to context *other than user interaction*.

In contextualization through *user interaction* two different types may be distinguished: while *explicit interaction* requires the user to tell the computer what he or she expects it to do, *implicit interaction* describes a user's activity that is not aimed at controlling a system, but that is interpreted by the system as an input or command (Schmidt 2000). For example, a user walks through a door, causing the lights to go on.

While it is easy to enable interaction capabilities – a sensor or camera together with a hard and software architecture might already allow interaction between users and screens – the challenge is to establish the interaction itself (Maeda et al. 2010; Kuhlman 2009). In fact, (potential) users do not pass a digital sign with the intention to interact with it, since they are typically concerned with other activities (another 'primary task'). Hence, two main barriers need to be overcome: first, the attention of the audience must be caught. Avoiding negative externalities and carefully considering the content of displayed advertisements are important issues when competing for the (limited) consumer's attention. Second, the audience needs to be motivated to interact with the display. To date there is limited knowledge on how to design displays in order to do so. Still, a certain degree of users' curiosity or play instinct is likely to help in stimulating interaction: "curiosity is evoked through novel stimuli that

present something unclear, incomplete or uncertain" (Müller et al. 2010). Despite the barriers that interactive digital signage faces, empirical studies could show that interactive signage was perceived to be more appealing to users in comparison to the presentation of pure, one-way information (Exeler et al. 2009).

One emerging interaction option is the use of gestures, which represent an expressive and powerful communication modality and provide excellent opportunities for the interaction with digital signage (Chen et al. 2009). They are often extremely present, either in the form of (conscious) hand gestures, or in the form of unintentional communications. A great variety of gesture-sensing technologies (e.g., video-based gesture recognition) exists already (Kuhlman 2009), which provides opportunities for integration into digital signage systems (e.g., Chen et al. 2009).

Another alternative is the use of a consumer's mobile device (e.g., smartphone) to interact with the digital sign. Using Bluetooth or other short-range wireless technologies, which are implemented in most smartphones, the mobile device could be used to connect to the digital sign and become a remote control for the display (Want, Schillit 2012). Want and Schilit (2012) argue that mobile remote controlling may be an effective method of low-latency interaction.

Besides interacting with a user, a digital signage system may adapt to context that does not depend on user activities – neither explicitly nor implicitly. Essentially, the trigger for adaptation may not even be concerned with a person. For instance, a system may display different kinds of advertising dependent on the weather, the light conditions, the crowdedness in front of the display, etc.

When considering diverse contextual adaptation mechanisms with digital signage, a major challenge arises concerning *continuity*. In particular, this is a major difference between contextual advertising on the Web and contextual advertising via digital signage. Digital signage is challenged to present a continuous program (a series of advertisements and/or other content), since showing an empty screen between advertisements entails negative effects because it appears to beholders as if the screen were broken; this, in turn, would probably deteriorate the space owner's image. An option would be to present information or entertaining content between sold, externally triggered advertisements. If demand exceeds the

supply of advertising slots, the risk of not having any advertisements is low. Still, some sets of context combinations may be highly valuable for a scale of advertisers, which they compete for, while other contextual situations may not be interesting. In such situations, where the risk of a black screen is present because a time slot has not been 'sold' to an advertiser, an option would be to show general (contextual) information or entertaining content on the screens.

3.5 Configuration Requirements of a Holistic Digital Signage System

Against this background of various issue-specific considerations, a holistic digital signage system needs to fulfill a whole range of requirements depending on the chosen service configuration. In the following, several configuration options are discussed, which are structured alongside the market players. With respect to the *advertiser*, it is important to have information about the budget for advertising, either in a specific setting or for a specific product. With the variety of options that digital signage offers, the target group of the advertiser's product or service is another important consideration, particularly if one considers implementing interaction possibilities. Finally, it has to be taken into account what specific strategy the advertiser pursues. Fig. 3 illustrates an exemplary rule set and backend services with two activity diagrams according to UML standard (Rumbaugh et al. 1991).

Since setting up a successful system requires information from *consumers*, at least to some degree, a specific consumer trigger has to be considered. Storing a consumer profile, for example on a loyalty card, is already common practice in many stores. Another option is to keep track of the profile via the consumers' mobile devices or via RFID chips. In such cases, the interaction component ensures that the (personalized) information displayed is associated with the bypassing consumer(s) at hand (Müller et al. 2010). With the latter approach, respecting consumers' privacy becomes an issue that deserves attention. Although customers are increasingly willing to provide information about themselves in return for a customized service, properly addressing privacy concerns remains an important issue (Simoes et al. 2009).

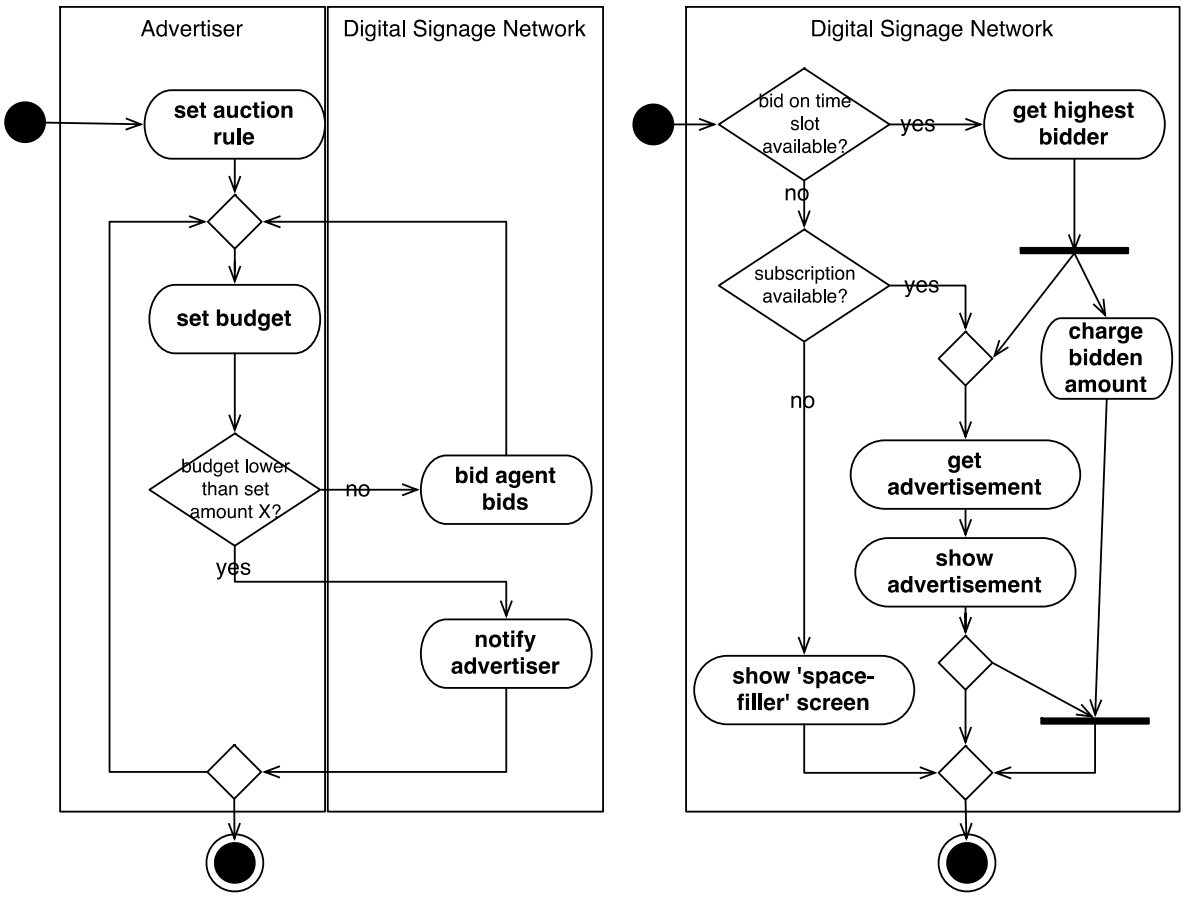

Figure 3. UML activity diagram for an exemplary rule set and backend services

Also for the *provider*, a certain trigger is needed. Taking the example of a grocery, having the information about what stock is available in shelves, enables the retailer to develop an appropriate strategy. This strategy could then be tailored in order to, for example, maximize profit margins (price differentiation) or sell complementary goods so that profits may be increased. Minimizing the vendor's inventory may be a potential strategy if the supply chain performance is an important issue. Similarly, supermarkets could pursue a strategy, which tries to minimize stock of perishable goods in order to avoid 'expired products'.

Finally, it has to be decided how to tailor digital signage to the situation at hand, i.e., what polling as well as pricing strategy will be used. As previously mentioned, a multitude of options exists for the polling of advertisements. In general, three basic options can be

outlined. First, fixed time slots for both time and location can be used. Second, the polling of advertisements can take place purely based on, for instance, the highest bid (auctioning) without having time and location constraints. Third, and this appears to be the most likely option for large digital signage networks, a hybrid solution can be chosen, where the majority of time slots is fixed with respect to time and duration, and the remaining slots may be sold via auctions. Regardless what polling mechanism is chosen, it is always linked to the pricing mechanism that is used: either one decides to have fixed prices (first and third option), or uses an auction mechanism to pick the highest bid for certain advertising slots (second and third option).

Platform providers may adjust their pricing according to the interest in the locations. This will, in the long run, lead to a closure of less attractive – and, thus, less lucrative – locations. Accordingly, the market curtails information flood and overstimulation in a self-regulatory way. This postulation is based on the assumption that less attractive locations are those, which do not reach a sufficient number of consumers that spend attention to the displays or advertisements.

Fig. 4 presents how these dynamics might work in practice, in form of an exemplary scenario. It shows that the advertiser subscribes to the digital signage network, and subsequently bids on desired slots. The advertiser then provides the content, whereas the space owner grants access to the displays. This space owner typically cooperates closely with the platform provider, who monitors the location preferences of the advertisers, but also consumer preferences. Additionally, a(n) (external) context information provider might offer pre-processed, already aggregated contextual information. Advanced systems might be able to offer real-time contextual information and adapt the displayed advertisements accordingly. Eventually, the consumer might be able to interact with the system (e.g. by a simple like/dislike vote via a mobile device). Note that the polling of advertisements might be influenced by such interaction.

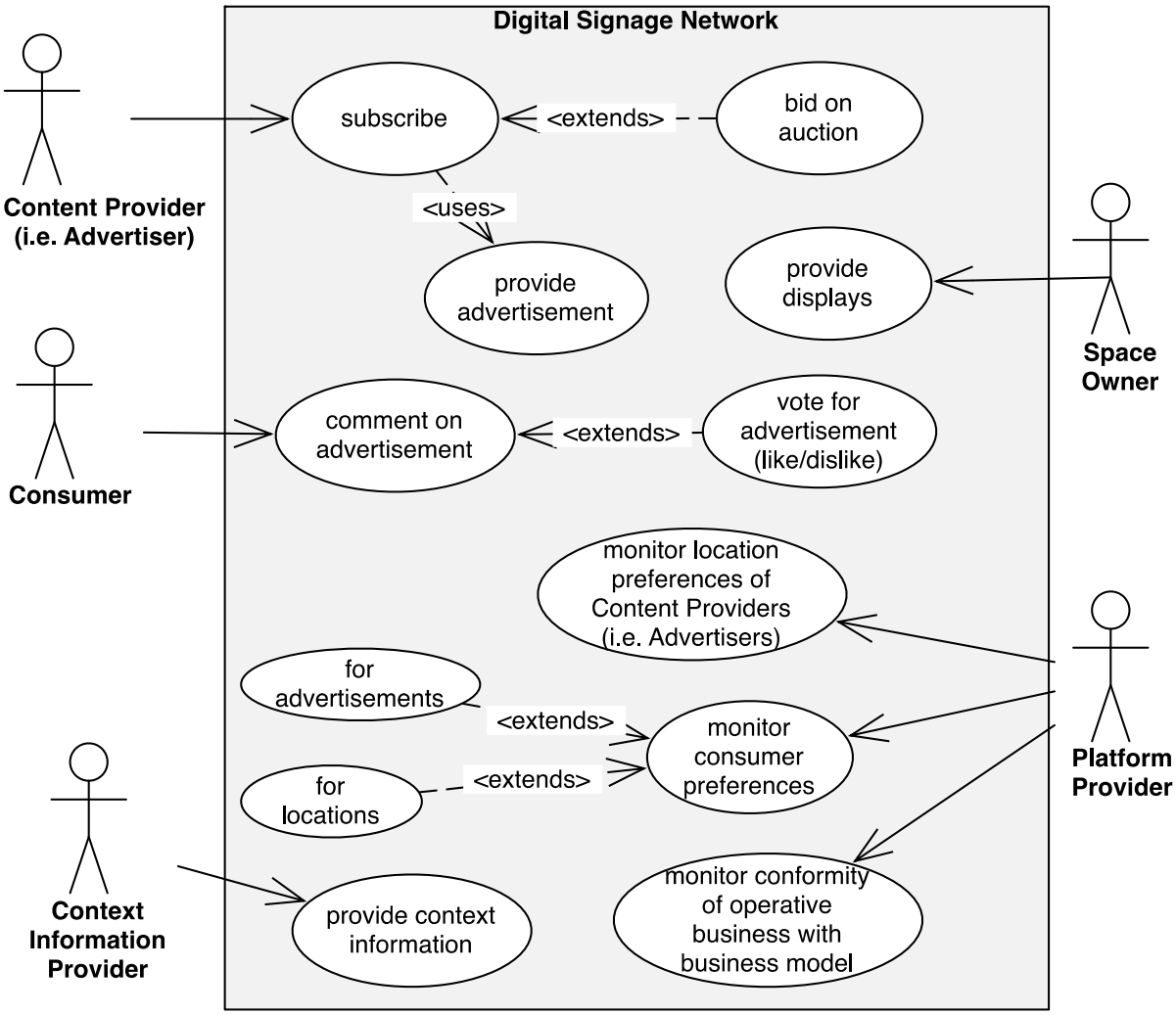

Figure 4. Exemplary UML use case diagram, displaying market players, their activities and backend services

While Fig. 4 presents the market players' standalone use cases, the activities are more complex due to the players' interactions. Basically, the consumer interacts with the system and is not directly concerned with other market players (i.e., pure human-computer interaction). The space owner and the platform provider will typically closely cooperate because, for instance, location preferences can indicate where exactly the space owner should position the displays. In active business, advertisers will interact with the system for providing advertisements and bidding on auctions. Still, interactions with the platform

provider could put them into a position to be granted access to consumer preferences data, which they can use for their advertising strategies and which could influence their bidding behavior. Context information providers will adjust their portfolio and probably also their business model based on the platform's use of their offerings. Additionally the platform provider will have motivation to cooperate with context information providers in order to receive the context information he or she needs, and in a way that he or she requires it. Only then he or she can offer advertisers the basic information they want to react to with their contextual advertising strategies.

4. DISCUSSION

The developed conceptual framework integrates the consideration of market players' roles, application location categories, strategies, and contextualization types. Multiple different combinations (configurations) are viable when setting up a digital signage system, since every design option implies several subsequent possibilities that might be chosen for implementation. This paper's goal was therefore to pinpoint at the various options that have to be taken into account when designing a contextual digital signage system, as well as outlining the variety of possibilities at disposal for each category. We want to emphasize that this conceptual framework is not yet exhaustive; neither do we exhibit certain preferred strategies within this sequence of choices in the current state of research and development. By outlining the conceptual framework we rather span the design, research and implementation space for future work.

Currently, contextual digital signage is in an experimental phase, facing several drawbacks. First, it is questionable whether this form of digital signage is without negative externalities. Second, deciding on which content to show in which context is a major difficulty (Müller et al. 2009a) that is still not sufficiently researched. Third, the public might well disapprove the use of contextual digital signage on the basis of privacy protection (Kobsa 2007), which might also turn out to be a legal barrier to take (Müller et al. 2009a). Opt-in solutions might be the best alternative to overcome privacy concerns (Kobsa 2007).

When advertisers indicate (in an auction) how they value advertising at a certain place and time, advertising space can be efficiently sold. However, it is important that consumers

consider the presented information to be relevant. In order to increase relevance, advertisements with interaction possibilities might be valuable because they have the potential to facilitate a two-way interaction with the audience.

Possible drawbacks are, again, privacy issues. Interactive scenarios with consumer feedback, though, counteract this problem by using the opt-in solution, which seems to be the most acceptable privacy-sensitive model. Yet, consumers' acceptance of receiving personalized advertising in public space, in contrast to personalized online advertising that they receive in their private space, is still to be investigated. A first indication provides a study by Malheiros et al. (2012), who found out that consumers frequently feel that personalized advertising intrudes their privacy eve on the Web. And as a consequence these consumers develop negative emotions towards the advertised product and/or company.

With regard to the opt-in model, large investments are required on a hardware and software level. Additionally, gathering consumer information for adequately specifying preferences takes effort and requires time until the system works satisfyingly for both, consumers and advertisers. Furthermore, when introducing interaction features, one appeals particularly technology-minded people, who would be the ones using these features. However, this implies that the 'digital divide' would increase, while political endeavors actually try to close this gap.

4. CONCLUSION AND OUTLOOK

Digital signage has started to play an increasingly important role in today's advertising industry and has become a significant technology-driven field. This enhanced mode of advertising provides a vast amount of opportunities, due to innovative features that allow for contextualization and interaction, and allows for customized and target group-appropriate advertising. Along with increased application options, a variety of choices have to be taken concerning backend services when setting up a contextual digital signage system. Accordingly, there is an urgent need for a cohesive and flexible conceptual framework in order to provide sustainability in research and applications. Particularly, the entire set of market players in their different roles needs to be considered, because each market player needs to be provided with appropriate services on the backend of a digital signage system.

This paper's main contribution is the provision of a conceptual framework, which defines the involved market players and their roles, application location categories, strategies and contextualization types and, thus, includes the requirements for those services that are essential to digital signage. It enables researchers and practitioners to perform further work, contributions and evaluation effectively using concise terminology and placement of functions, roles and strategies. Furthermore, the framework supports sustainability as it allows researchers from various disciplines to position their contributions in the space of the proposed framework. From an industry perspective, the framework also provides sustainability for real-world applications, as it provides decision support when setting up a digital signage system by making the system components' impacts on the market players transparent.

Particularly, contextual digital signage represents a new, technology-driven field requiring original and genuine services on the backend. The need for such services will attract new players to enter this emerging market, whereas established players will adapt and seize the new opportunities. Consequently, leveraging this new branch of business eventually affects the entire advertising market as most players originate from traditional segments, where they, in turn and as a reaction, will adapt their strategies. An analysis of possible market dynamics will support entrepreneurs and established players in their strategic decisions. Consequently, future research shall focus on market dynamics of contextual digital signage, the impact of those dynamics on service requirements, and the outline for legal issues in the field in its broadest sense. Hence, key questions for future research are: How shall distributed backend services be operationalized to best cope with market dynamics? What are the pricing parameters and pricing mechanisms for services in complex contextual digital signage systems? How should efficient auction mechanisms and services be organized and designed to allow real-time reaction?

Research on backend service-related questions shall be integrated into the proposed conceptual framework, as this would foster sustainability. We emphasize that backend services lay the groundwork for a digital signage system. Applications, strategies, or frontend services (e.g., presentation on a screen), or additional backend services (e.g., analytical services) can only work efficiently, when they are built on a well-elaborated base.

Accordingly, we suggest that research on backend service-related issues shall be prioritized in the community, as those services form the crucial basis for a successful application of digital signage.

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