The Business with Digital Signage for Advertising

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Abstract. The market for digital signage has been growing at an accelerated pace for years. The benefits of novel approaches – such as contextualization and interaction functionalities – were soon recognized for achieving better advertising effects. However, the major types of digital signage currently in use have different requirements on the entire digital signage system. These requirements include components such as the digital signage network, digital signage exchange, scheduling, and pricing. The present paper discusses the differences between these components in depth. The core contribution of this paper is a detailed analysis of the potential of digital signage. Emphasis is placed on challenges in performance measurement and implementation, operating and using a digital signage system, display blindness, and negative externalities. Possible solutions, as well as best practices are presented. At its core, this paper provides an overview of the essentials of doing business with digital signage.

1 Introduction

The digital signage market has been growing rapidly for years, and the end of this growth is not yet in sight. According to various recent studies, the growth rates in digital signage market are expected to continuously grow until 2018. Positive growth rates will not only appear in digital signage hardware industries, such as digital signage displays, media players, set-top boxes, and PCs, but also in digital signage-related infrastructural markets, such as software and services (cf. e.g., [1, 2]). A major factor in the wide-spread growth of this technology was the fall in the price of LCD screens, which are considered as the crucial hardware component in digital signage. Electronic (i.e., digital) displays used for digital signage offer new opportunities and advantages compared to traditional 'static' signage. For instance, digital technology allows information to be displayed in the form of dynamic multimedia presentations containing audio, video, and animated content (cf. [3]). Additionally, remote access to the digital signs and central scheduling within a digital signage network allows displays to adapt their contents based on both time and location. Adding additional systems and sensors to the digital signage network allows displays to exploit various additional information sources leveraged to better catch the audience's attention.

Digital signage is appropriate for various application areas. The broadest application is the point of sale (POS); the majority of applications in Western Europe take place in (public) transport areas, followed by leisure and gastronomy areas. Compensating for those groups of people that are nowadays quite hard to reach via traditional media such as newspapers and television commercials, digital signage might provide superior opportunities to approach this audience in a target-oriented manner. Several authors (e.g., [4]) claim that, to date, not much attention has been paid to the phenomenon of digital signage in academic literature. The quantity of literature elaborating on this topic might indeed be limited. Nevertheless, several interesting approaches investigate the related dynamics between digital signage and consumer reactions [5], interaction alternatives 4], [6], and strategic issues [7].

This paper will explain the major types of digital signage that are based on currently used technologies (Section 2). To provide an insight into the essentials necessary for digital signage business, this paper will outline digital signage system's infrastructure, forms and specific aspects that have to be taken into consideration; digital signage network, digital signage exchange, scheduling, and pricing are discussed in detail (Section 3). The core of this paper will analyze the potential and the challenges of digital signage (Section 4): challenges in implementation and performance measurement, in display blindness, as well as negative externalities and possible solutions together with best practices will be presented. The paper concludes with a summary and an outlook on further research alternatives.

2 Current Types of Digital Signage

Digital signage is a promising medium that prevails over the information clutter, because digital displays provide new opportunities and advantages over traditional 'static' signage [8]. For instance, digital signage displays dynamic presentations containing audio, video, and animations [3]. In contrast to traditional physical signs, digital signage virtually eliminates the costs of content distribution. In addition, a digital signage system can dynamically change content on its displays within milliseconds. This allows displays to present various advertising messages according to a schedule [9] or that are triggered by particular events.

The term "digital signage" describes networks of displays in public space. While digital signage may be employed for various purposes, e.g., displaying news, tourist information, or flight schedules, this term is most frequently mentioned when a display network is used for advertising [8]. Still, in the context of advertising, the term "digital signage" is quite often misplaced, as it is used to refer to any kind of shop TV or stand-alone screens in stores. For the scope of this paper, in line with [8] and [10], we define and use the term "digital signage" for a dynamic, networked, visual or audio-visual information system consisting of several decentralized digital displays, which are interconnected with a central system (consisting of a content management system and a user rights management system) that allows for a remote control of the displays.

There are various types of digital signage solutions used on the market. Based on the location of deployment, we distinguished indoor and outdoor digital signage solutions. Most common examples for indoor solutions are interactive kiosks that are deployed in subway stations, shopping malls, or at airports. In recent days, some fast food chains have also recognized the value of the digital signage and applied those at their point of sale (POS). Most recognized examples of outdoor digital signage solutions are LCD screens deployed in the biggest public areas such as Times Square in New York or Shibuya in Tokyo, stored in a secure and weather proof TV enclosure.

Beyond placement, digital signage may be distinguished based on the application area [11]. Most solutions are deployed at a point of sale (POS). These are typically comprised of in-stores signs that strive for a consumer's attention in order to cause a conversion. At POS, the usual intended conversion is sales uplift. In these cases, the call to action is immediate as the screens are placed directly at the place where the consumer is making buying decisions. Another application area is represented by point of transit (POT). These advertisements are trying to grab attention of passers-by for a short time. The main purpose of these screens lies in the establishment of brand identity. The third application area is point of wait (POW). At such points, consumers have sufficient time to look at the signs and therefore the advertiser may use different tactics to engage the consumer's attention (e.g. more repetitions, longer advertisements with persuasive character). Examples of digital signage at POW are typically found in healthcare, retail banking, and office buildings [8].

2.1 Contextual Digital Signage

Providing relevant content is the key for sustainable advertising effects [12]. For instance, on the Web, contextual keyword advertising is known for its effectiveness: Advertisements that are related to search keywords appear next to search results (e.g., market leader Google's AdWords [13]). Equipped with

respective context-capturing sensors and other technologies, digital signs can adapt instantly to fit the situational context [9], [14]. Regarding advertising, this means that the digital signage system selects and displays advertisements based on contextual triggers such as time, location, weather, characteristics of beholders, etc. [15, 16].

Based on this information, in line with [8], 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".

In essence, contextual digital signage ensures that the advertisements are better targeted to the consumers as well as the current situations. Hence, the advertisements have a higher probability of being relevant and they gain more attention [12].

2.2 Interactive Digital Signage

Recent research emphasizes that interaction possibilities are able to increase consumer value by raising consumer engagement [17] or emotional perception [18]. In addition, digital signage may be enhanced, allowing consumers to interact with the system.

For instance, consumers may engage actively and intentionally with a digital sign-age system by touching a touch screen. In other implementations, consumers may interact implicitly with the system, with particular movements, for example. Vogel and Balakrishnan [19] presented gesture-controlled displays, interacting with passers-by according to the proximity to the screen. Müller and Krüger [20] developed a solution that can learn from its experience and, based on this information, can influence the advertisement scheduling and selection mechanism.

To conclude, interactive digital signage allows for greater involvement of audience, better user experience, and more accurate targeting.

2.3 Interactive Digital Signage with Mobile Devices

The advancement of information technologies (e.g., Radio-Frequency Identification (RFID), Bluetooth, gesture-sensing technologies) and the increased adoption of personal mobile devices equipped with such technologies (e.g., smartphones) make interaction an increasingly attractive option for furthering consumer engagement.

For instance, when a consumer approaches the coverage of a display, prepared advertisements may be supplied to the connected mobile device of the respective consumer [21]. Thereby, the connection may be accomplished via Bluetooth or Wi-Fi, for instance. A widely known example for this kind of interaction is the sending of vouchers via Bluetooth or SMS to the consumer's mobile device. An additional popular implementation is having consumers scan a Quick Response (QR) code on a display to receiving an advertisement or voucher on their personal mobile devices (cf. [20]).

Other solutions for interaction include using a personal mobile device to control the content on a nearby public display. As the short-range wireless communication technology minimizes delays between user and sign, it may be an effective method of low-latency interaction [1].

3 The Essentials for Digital Signage for Advertising

As outlined in Section 2, a digital signage system may be designed and implemented in various ways. Accordingly, there are also different business requirements that have to be considered when deploying a digital signage system. The following subsections provide an overview of a digital signage system's

infrastructure, forms and the specific aspects that have to be taken into account in order to achieve a positive business performance.

3.1 Digital signage network

A digital signage network (DSN) connecting various displays significantly shortens the conventional CDI (creation, distribution, installation) cycle of a particular advertisement [45]. When an advertising campaign is designed, it can be directly and quickly transferred to some or all displays in the network. Compared to conventional signage, several steps, such as physical sign creation, distribution, and installation have become obsolete in a DSN (Fig**. 1**). On the one hand, the implementation of digital signage involves relatively high initial investments. On the other hand, the flexibility in content and the promptness of changing the content remotely leads to significant cost savings [8].

If a digital sign is located at the POS, for instance at a supermarket, the retailer's inventory system may be interconnected with the DSN. According to the current availability of a product at the respective retailer, a particular advertisement may be pushed or paused. This scenario is only one of the vast possibilities for *contextual* digital signage. In addition to the information about the inventory status, contextual data is also important when providing dynamically configurable promotion. If further contextual cues should be considered for a contextual digital signage system, the respective hardware and software needs to be interconnected to the DSN. For instance, if an advertisement should be selected based on the current weather situation, a connection to a service providing this information has to be established. For the specific case of weather information, two solutions are viable. Access to a Web service providing weather information for a particular region is one solution, while weather-eliciting hardware (e.g., thermometer, wind gauge, etc.) can also be installed on site to provide the required information. In the event that characteristics of an individual nearby a display should trigger a certain advertisement, additional hardware and software solutions need to be installed on site. First, technology recognizes the presence of an individual has to be implemented; second, personal characteristics of the individual have to be captured (e.g., a camera may take a picture of the individual); and third, the captured information has to be analyzed (e.g., the individual's hair color needs to be analyzed based on the picture) and matched against predefined criteria (e.g., display the suitable hair coloring advertisement for the detected hair color).

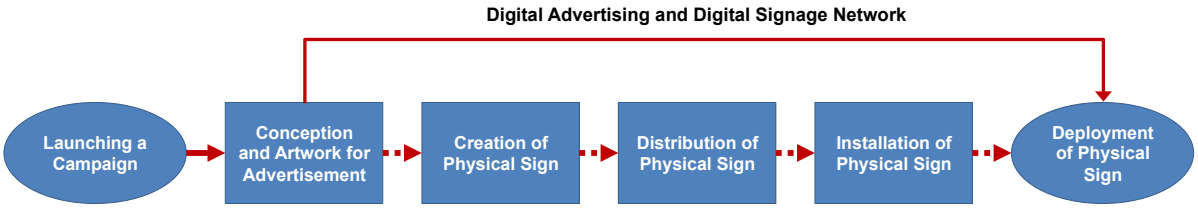

Fig. 1. Physical Sign vs. Digital Signage in the CDI cycle (based on [45], p. 166)

For interactive digital signage, respective hardware has to be installed on site with every display on the network that should have the specific functionality. Touch is a typical interaction modality; it certainly requires a display to have touch functionality to enable this interaction type. Using a consumer's posture as the trigger for advertisement selection requires other hardware. Solutions found in literature typically use cameras and/or (Kinect) depth-cameras for being able to capture posture information [22, 23].

For having consumers interact with a digital signage system via their personal mobile devices, hardware has to be available on site (e.g., RFID scanner, Bluetooth). Care must be taken to build on technologies that are supported by widely used mobile devices. For instance, Near-Field Communication (NFC) solutions were implemented in Europe's kiosk systems long before Europe's mobile devices were equipped with

such technology. This situation resulted in a wide-scale non-use of those solutions. In addition, consumers developed not-so-positive attitudes towards these systems, as they were not in a position to use them.

3.2 Digital Signage Exchange

To allow for the appropriate distribution of advertising space within a digital signage network, there is a need for digital signage exchange (DSE). Harrison and Andrusiewicz [45] describe DSE as a partially automated, supervised broker that mediates between sellers and buyers. The seller is defined as the entity that owns and controls digital signage solutions. More precisely, the seller may be the platform provider or the space provider. The buyers are usually advertising companies, interested in purchasing time slots for their clients.

Depending on the type of digital signage system employed, there may also be other entities participating in the DSE part, namely an (active) consumer, a space owner, and a context information provider [8]. The interactive feature of digital signage may, for instance, provide consumers with the option to comment on advertisements; these comments may be leveraged to adapt advertisements in future advertising cycles to the specific needs and preferences of the respective consumer or group of consumers.

Overall, DSE is an intermediary between all the involved players on the digital signage market. It is based on schedule management or – if time slots are sold by an auction mechanism – an auction bidding may decide which advertisement is displayed at what time on which display and at which price. This decision process is called transaction management model [45].

3.3 Scheduling

Getting the right message to the right audience and at the right time is the key element for providers of digital signage solutions. Storz, Friday and Davies [24] state that the scheduling for collaborative displays (i.e., digital signage systems that enable users to share information) is mainly determined by an individual's interaction. Thus, the individual directly decides which content will be shown and there is no need for a complex scheduling system. On the other hand, the informational signs typically employ for scheduling looping playlists where the orders of other players/advertisers may impact the entire selection process.

The main function of DSE is to provide accurate information about available dis-play time to buyer and seller. When a new order is placed, the DSE generates a partial schedule. Based on this schedule, the system calculates how many other orders may be accommodated. If the new or next order is placed, the system compares the partial schedule with the proposal and either accommodates the order as requested or pro-poses a counter-offer [3].

For contextual and interactive digital signage, Müller et al. [14] propose an autonomous machine learning mechanism using a so-called Naïve Bayes classifier that can apply scheduling strategies obtained from previous observations of the audience. Their concept consists of feedback loops, i.e., the digital signs adapt their content based on audience reactions. Thus, when the system recognizes that a person reacted on a certain sign under certain circumstances, it prioritizes this advertisement next time in a similar situation [14] (**Error! Reference source not found.**). Not only the buyer's order or contextual data, but also other factors may influence scheduling. Each deployment of digital signage is striving for financial sustainability. Therefore, there is a need for appropriate pricing mechanisms, which provide relevant information for an adequate scheduling system.

3.4 Pricing System

Assuming that the platform provider (digital signage service provider or seller) aims to fulfill advertisers' needs (i.e., pushing the exposure of an advertisement in the advertising cycle and offering intended conversions), auction mechanisms seem to be a feasible option for pricing. In such cases, auction

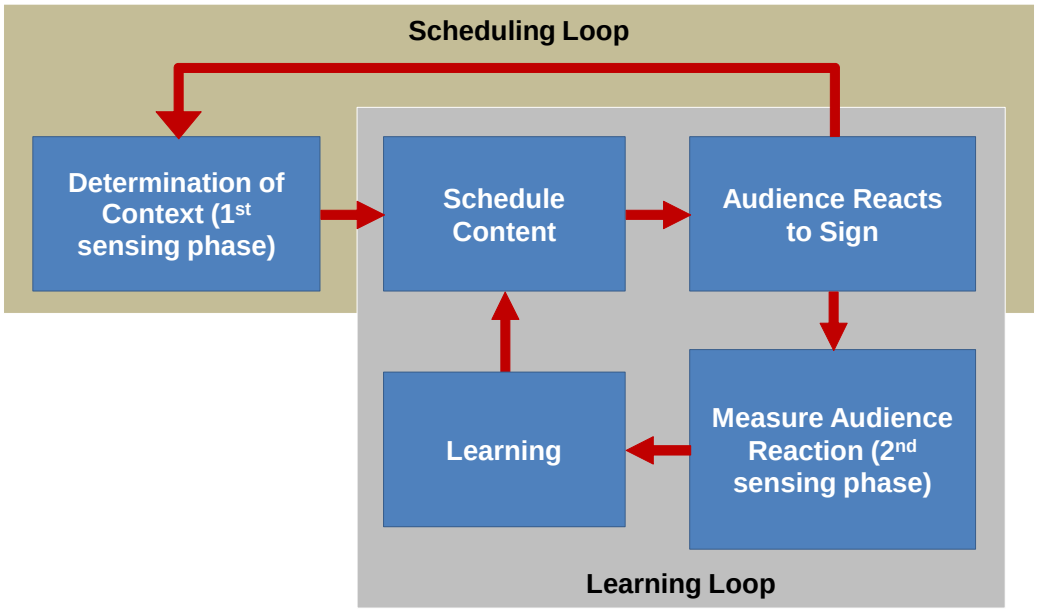

Fig. 2. Machine Learning for Scheduling in Digital Signage: Information Flow and Loops (adapted from [14])

mechanisms typically lead to much higher conversion rates (up to 64% as reported by [25]) than classic selection approaches such as the Round-Robin approach or Random approach.

Contextualization and interaction add aspects that have to be considered in a pricing system using auction mechanisms. Based on contextual information such as video captured by an integrated camera, a Bluetooth device connected to the digital sign, location or time, the most suitable advertisement even for lower bidding price may be favored and viable conversion rate achieved [26]. In general, the auctioning selection process consists of an advertising agent that is responsible for purchasing advertising space, and an auctioning agent that saves a history of successful advertising cycles (i.e., history of cycles in which the buyer won the auction, the respective advertisement was shown, and conversion was achieved). Based on these results, the system favors/disfavors an advertiser's bid in the next auctioning cycle [25]. This example is just one of the many used in practice. There are various algorithms for computing bids and consequently displaying advertisements. For example, Google has never completely revealed the bidding algorithm hidden behind its AdWords service. In order to utilize the auctioning process, Google also takes advantage of contextual data and applies it in the AdWords' auctioning mechanism. Buyers with higher Google page rank, more keywords, or better link quality need to bid less than those buyers with a poor rank or fewer keywords. In conclusion, this strategy will favor relevant buyers and produce appropriate results for the audience.

In general, the auctioning mechanism adopted in the field of digital signage in practice currently applies a second price auction [25]. The winning advertiser will never pay more than one bid increment above the bid amount of the advertiser in the second position, meaning that the winning buyer gets the time slot for the price of the bid of the second higher plus an increment, and the second buyer pays just one bid increment above of the bid of an advertiser in the third position; the amount of an increment bid varies between platforms but is generally about USD 0.01 [44].

4 Potential and Challenges of Digital Signage

4.1 Potential of Digital Signage

Digital signage is a promising and very attractive platform that has already gained its fixed place among other advertising tools. Digital signage offers some special features and benefits in comparison to the conventional, static form of campaigns. Based on its direct connection to the provider, a digital signage solution offers quick, effective and flexible controlling and displaying of content. The fast, flexible and on the fly update through the DSB, without the need to interact with the signs physically, eliminates high costs in comparison to creating and distributing print advertisement campaigns. Moreover, the possibility of selling advertising space to their suppliers contributes to the financial advantage of this solution screen providers too. Interactive digital signage is also more engaging, more informative, and offers targeted content that can grab a consumer's attention right at the POS and positively impact sales. Based on the solution deployed, passers-by might be enabled to interact with an advert through several technologies (e.g., Bluetooth, Wi-Fi, motion sensors). As the attention of consumers increases, such solutions also lead to a better Return on Investment (ROI) and lower financial expenses for CDI [8], [45]. However, many retailers still use paper-based promotional material in their retail outlets and are only beginning to upgrade to digital displays ('digital signage') [9].

There are several major arguments supporting the business rationale for deploying digital signage. Current trends demonstrate that the conventional way of attracting consumers is connected with high costs of CDI in terms of labor and material [45] and that using digital signage generates additional business value. Major applications of digital signage and drivers determining the underlying business rationale are selling display time (third party advertising), increasing sales, brand messaging, entertainment, internal communication, and alerting (cf. [27, 28]).

4.2 Challenge of Performance Measurement and Implementation

Deploying any digital signage solution requires, from a managerial point of view, the ability to measure the impact of these signs on the target achievement. Currently, the majority of providers usually give only approximate numbers of passers-by exposed to a screen [29]. However, there are also other approaches such as, for instance, In-Store Marketing Institute and VNU partnership on measuring the impact of digital signs in cooperation with supermarkets. In general, the measurements are accomplished individually, making it impossible to draw a cohesive conclusion on the results [30].

The lack of a *unified* standard represents a major challenge. The existence of such a standard would boost the overall development in this emerging field, but would at the same time interfere with market forces and competition. So far, several approaches have been established as quasi-standards. These standards are POPAI, SMIL, and HTML 5. The W3C consortium is preparing to launch a standard platform, which will potentially result in additional cost reduction of content acquisition and transmission in this field [31]. The initial workshop was held in 2011 where the needs and requirements of big digital signage users were consulted [28]. **Error! Reference source not found.** provides an overview on the two most widely used quasi-standards, i.e. SMIL and POPAI.

4.3 Challenges of Operating and Using Digital Signage Systems

Operating the involved technologies poses challenges to advertisers as well as to consumers (cf. Tab. 2). For instance, many consumers have problems enabling Bluetooth on their mobile devices. Therefore, the camera (which is typically heavily used by most mobile device users) may be the better choice as the main transmitter of information for interactive digital signage. Vogel and Balakrishnan [19] also tested novel interactive public ambient displays that react to gestures and the distance of passers-by to the display. Their research showed that these techniques are essentially easily and fast discoverable and useable. Still, it is

Tab. 1. The quasi-standards SMIL and POPAI [31, 32]

SMIL	POPAI
• XML-based mark-up language for describing playlists, schedules and screen layouts • Open standard established by the W3C • Mostly used in USA, Germany, Denmark, France, and India • One hardware vendor may drive about 100,000 screens using SMIL-enabled digital signage devices	• Similar use like SMIL • Most commonly supported formats are: MP3, .AAC, .PCM, A-law, U-LAW, DiviX, Xvid, x264, .bmp, .jpg, .gif, .png, .avi, .mov,. asf, .mp4, TS, PS • Pros: no dropped frames for video, no noticeable distortion of audio and still images from original

very important to bear in mind which target group should be addressed, because it is the younger generation that pays attention to and interacts with interactive digital signage [20], as they are more accommodated to the technologies involved.

Furthermore, as various new technologies may be deployed in digital signage, such as gesture-based recognition (e.g., [6]) or body tracking systems (e.g., [33]), many additional challenges arise. Currently, major efforts are still necessary to bring those systems on a level that allows for easy and user-friendly interfaces for consumers.

Tab. 2. Challenges of operating digital signage systems for advertisers and consumers (based on [14, 20])

Advertisers	Consumers
• The most important system feature for advertisers was measurability of advertising success followed by optimization of location • Advertisers tend to rely on the proposed scheduling by system, as scheduling effects currently are not sufficiently explored • Advertisers find it difficult to design their own campaigns with respect to contextualization and interactivity • Advertisers expect marketing support for digital signage solutions from advertising agencies due to a lack of knowledge with the technology • Before deployment, advertisers seem interested in controlling their campaigns (which sign, when, how, statistics); thereafter they tend to rely on the efforts by digital signage providers • Location is more important than content	• Consumers tend to prefer taking photos of coupons rather than having to operate Bluetooth or SMS solutions • The location of a display is very important in order to attract a consumer's attention • Younger generation/digital natives may be targeted with highly interactive solutions, while older generations/digital immigrants may have difficulties operating the involved technology • Interaction process may be perceived to be initially difficult for passers-by (understand how to interact with an interactive digital signage system) once they understand how to interact, people state that they enjoy using it • When the purpose of the camera is not explained, people tend to feel being "securely watched"

Besides consumers, many advertising companies also face challenges in operating digital signage systems. For instance, Müller and Krüger [20] revealed that retailers lack the knowledge and competencies to design and configure their potentially interactive or contextual advertisements. As a result, providers of digital signage systems need to have comprehensive knowledge on complex issues and system properties to offer a full-package product to the potential buyer.

4.4 Challenge of Display Blindness

"Display blindness" is a major challenge for successful digital signage. The term was derived from a similar phrase, namely, from "banner blindness", which is characterized as the phenomenon of website users who are actively ignoring web banners [34]. Studies have confirmed that the "expectations towards what is presented on public displays can correlate with their attention towards these displays" [35]. Such display blindness is connected with an individual's informational overload (cf. [36]). When the advertising space is a scarce resource, digital signage is facing two negative externalities that can influence their deployment. Firstly, the local authorities can regulate the amount of advertising space. For the sake of these regulations, auction systems were recommended [12]. Auction mechanisms seem to be viable in terms of scheduling as well, since, compared to classic selection approaches, the conversion rate is higher [25]. Secondly, studies of [12], [20] revealed that there are still privacy concerns when using and collecting contextual data. Unfortunately, this data is crucial for contextual digital signage. As a result, in some cases the service cannot be tailored to the consumer's needs. There are several legal regulations must be taken into account. Generally, the person has to have the right to opt-out from collection of contextual data [37].

Furthermore, two major factors affecting a person's glance at a display have been identified: bottom-up effects and top-down effects (Tab**. 3**). Studies have revealed bottom-up effects that have impact on the display blindness (i.e., generating/increasing or reducing display blindness). Furthermore, studies indicate that displays at a POW receive more attention than displays deployed at a POT [14]. However, the location does not seem to have any effect as long as a person expects interesting information to be displayed. For instance, when the display was deployed in the school area, students expected interesting information, in contrast to the displays placed in the city center, which were considered as "just another ad". As a result, the displays at schools were glanced more often [14]. This underlines the influence of contextualization on consumer perception. Overall, the factors summarized in Tab**. 3** should be taken into consideration when setting up a digital signage system.

Additionally, Dennis et al. [4] examined the mediating factors on perception and emotions in terms of digital signage. People who are in good mood before shopping may have better perception of the products and – as a consequence – tend to buy and spend more [38]. Dennis et al. [4] add that advertisers may enhance this process by using sensory stimuli through the digital signage. They proved that digital signage has significant direct influence on the perception of the mall environment that consequently drives the consumer's willingness to buy and spend more (cf. [4]).

4.5 Negative Externalities and Possible Solutions

Digital signage faces the challenge of increasing effectiveness at locations engraved by information overload [40] as people are exposed to numerous advertisements in public space while the attention of an individual is limited. Paying attention to an advertisement can therefore be regarded as a cost for the consumer ("attention costs"). Only if the advertisement conveys useful information, while at the same time decreasing the attention costs, will the consumer see a 'net benefit'. An overload of signage, which is present at many places that are basically suitable for digital signage, is then simply the result of having more advertisements (causing too much costs) than would be 'optimal' [26]. Advertisers, however, do not directly calculate these costs, as they tend to focus on internal costs, such as costs for space rental or campaign design [9]. Consumers' attention costs are not included in transactions between buyers and sellers

of advertising space for digital signage (i.e., transactions between platform/space providers and the advertiser). This situation is described as a negative externality in digital signage advertising [26].

Tab. 3. Effects influencing display blindness (based on [14], [39])

Top-down effects
• Individuals' expectations towards the perceived content can reduce display blindness; e.g., from public institutions people expect more relevant information than from commercial entities, which results in people paying higher attention towards displays placed in public institutions • Location does not have any effect on display blindness if an individual expects some interesting or relevant information
Bottom-up effects
• Colourfulness and attractiveness reduces display blindness • Amount of display time; i.e., long distance visibility increases the probability that an individual notices the display • Size of display eliminates display blindness • Placing display in forward direction captures the attraction unintentionally • Displays that show video content tend to capture the eye longer than text • Displays at eye level or positioned considerably above the head draw more attention • Closer distance to other eye-catchers increases display blindness • Small displays may encourage prolonged viewing in public spaces to a greater extent than large displays

At first thought, one might consider not having any advertisements at all to be a suitable solution in order to deal with negative externalities. Weiser and Brown suggest the opposite: "It seems contradictory to say, in the face of frequent complaints about information overload, that more information could be encalming" [41]. This implies that information overload is not the actual problem. Rather, the fact that consumers become annoyed because they do not receive benefits in return for their attention seems to be the core problem here [42]. Hence, providing sufficient benefits to the consumer is the basis for not consuming attention costs unnecessarily in digital signage advertising, eventually helping to overcome the problem of negative externalities at the same time.

Receiving the consumers' attention is not a matter of bottom-up effects (e.g., screen size, animated advertisements or noise), but rather of providing relevant content [26]. This insight is a crucial starting point when considering solutions to avoid negative externalities. An analogy between the Internet and digital signage confirms this argument: e.g., pop-up advertisements with animations and sounds that appear prominently at the center of the computer screen are far less effective than contextual keyword advertising. Contextual keyword advertising consists of advertisements, which are related to search keywords and which are displayed next to the search results (e.g., Google AdWords [13]). The reason why those advertisements attract more attention is because they are context-driven and, thus, better targeted to the consumers and their current situations and aims, and have a higher probability of being relevant. In contrast, pop-ups appear much more prominently. These pop-ups have many detriments, including a higher risk of unnecessarily consuming attention from the Internet user, causing attention costs [26]. With digital signage, too much advertising can lead to suboptimal consumption of attention, as comparable with pop-ups. The analogy with contextual keyword advertising, in contrast, shows that advertisers could better rethink the relevance of the content, instead of engaging in an arms race of designing their advertisements more attention drawing [26], [43].

Coping with negative externalities by market regulation is an additional possibility. Theoretically, if negative externalities are eliminated, then the average consumer's benefit from giving attention to digital signage at a certain location is maximized. If the consumption of a consumer's attention could be monitored, for example via dual-task performance, one could sell the exact amount of advertisements until this benefit is reached. Müller and Krüger [26] discuss three options to achieve this aim: maximum permissible values, fees, and tradable certificates (cf. Fig. **3**). The following paragraphs discuss these three options and their pros and cons in detail.

The first option is regulation by *maximum permissible values*. Regulators may be sure about the amount and style of the advertisements. However, this method seems to be ineffective, because the costs caused to advertisers cannot be regulated, whereas every advertiser can only attract the same maximum amount of attention. The second option, charging *fees* for each unit of attention would solve the latter problem by letting advertisers pay more in case that an advertisement is worth more to them. This option would be theoretically sound, but practically hard to implement, because it is too difficult to determine how much should be charged for one unit of attention. This value should be equal to the costs induced to society, which is practically impossible to calculate. As a third option, one could work with *tradable certificates* (according to [26] a combination of the both previously stated mechanisms): If one would sell certificates for a certain amount of attention in a certain location, the average consumer benefit will be maximized. An auction can serve as the solution by filtering out which advertiser is valuing the opportunity to advertise at that moment and location most. The drawback of having high transactions costs with this approach might not be too relevant in the case of digital signage, since auctions are applied successfully in this market [25]. Automatic execution of the auction by software agents will then help to decrease these transaction costs to acceptable proportions [26]. This regulation of advertising market will, on the one hand, reduce information overload for consumers, but, on the other hand, it will support advertisers in targeting certain consumers and consumer groups, because just the relevant ones will be able to win the auction.

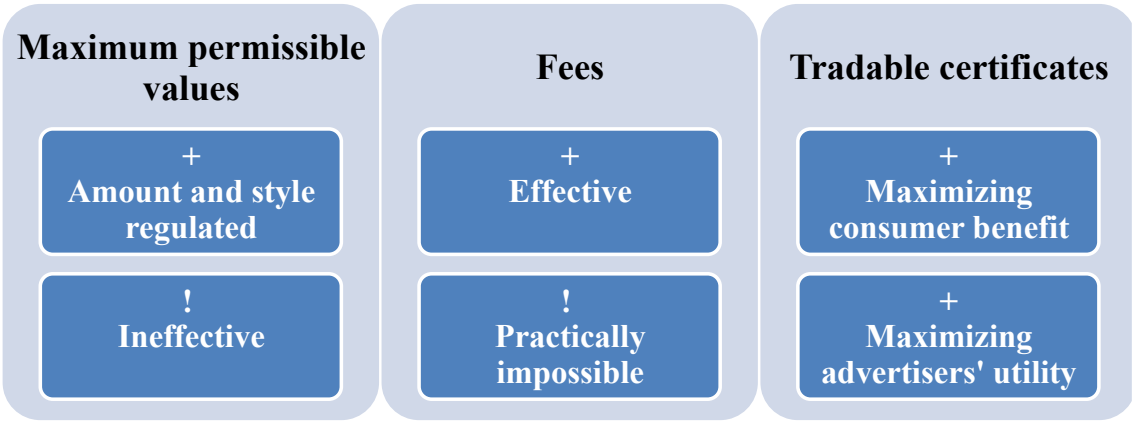

Fig. 3. Options for consumer benefit optimization in digital signage and their pros and cons

5 Conclusion

Digital signage plays an increasingly important role in today's advertising industry. This emerging mode of advertising provides new opportunities for consumers and for businesses due to its great array of possibilities. Along with the development of various types of digital signage and their increased application options, the need for diversified business approaches arises. The paper presented and discussed the different requirements and adaptation capabilities for the three major types of digital signage applications that are based on currently used technologies; the three major types are contextual digital signage, interactive digital signage, and the specific form of interactive digital signage with mobile devices. Particularly, this paper

discussed the essentials components necessary to create business value for each of the major types of digital signage, i.e., the digital signage network (DSN), digital signage exchange (DSE), scheduling, and pricing. The infrastructure of a digital signage system, its forms and specific aspects, have to be taken into consideration by companies which intend to participate in this promising market. As a result, our work targets both researchers as well as practitioners in the field.

The core contribution of this paper is a detailed analysis of the potential of digital signage; emphasis is laid on challenges of performance measurement and implementation. The lack of a *unified* standard represents one of the major challenges, the existence of which would boost the overall development in all the major types of digital signage. The quasi-standards SMIL and POPAI are already a step into the right direction. Another emphasis of the analysis laid on challenges of operating and using digital signage system; in this context, we discuss display blindness and negative externalities. Possible solution paths were discussed for all challenges and best practices were presented.

As existing studies show diverging results, future research may include empirical studies on immediate as well as indirect effects of digital signage on sales in various sectors. Further issues that could be examined empirically focus on content: Which type of content should be displayed, and should the content be communicated as information or as emotional advertising? Another thread of research will focus on the perception of content that might depend on sequences and/or on schedules of advertisements.

Contextual digital signage is for the time-being in an early phase, thereby facing several drawbacks; from a societal viewpoint the use of contextual signage might well be disapproved due to privacy concerns. Research may focus on technically-oriented and organizational alternatives to offer contextual content that is not only in line with privacy regulations but also meets the consumer's expectations on privacy.

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