MobiDiC: Context Adaptive Digital Signage with Coupons

Abstract. In this paper we present an approach to automatically tailor content on digital signage to the context. In a feedback loop, the signs sense their environment; decide which content to show, and then sense the audience reaction to the content shown. From this audience measurement, the strategies which content to show in which situation are refined. As one instantiation of audience measurement, we propose a novel simple couponing system, where customers can photograph the coupons at the signs. Thus, it can be measured whether customers really went to the shop. To investigate the feasibility of this approach, we implemented a prototype of 20 signs in the city center of Münster, Germany. During one year of deployment, we investigated usage of the system through interviews with shop owners and customers. Our experiences show that customer attention towards the signs is a major hurdle to overcome.

Introduction

As display prices continue to fall and new display technologies emerge, public space is increasingly penetrated by digital signs. Many stores use them for branding to improve the shopping experience, but increasingly digital signage is used to present advertisements from multiple advertisers. Such signs already exist in airports, train and subway stations as well as some public places, but we believe they will eventually replace paper signs everywhere. Because on digital signs the content can be exchanged every moment, the content can then be tailored to the context and the interests of the audience. Thus, scheduling becomes much more complex than for paper signs, and new technologies are needed to automatically decide which ad to show where and when. To enable such technology, it is useful to measure the audience reaction to content shown. Major challenges for digital signage will be the prevention of visual SPAM as well as the preservation of customer privacy. We hope that the approach presented here is a first step towards providing more interesting content on digital signs while preserving customer privacy.

Main contributions of this paper are:

1. A context adaptive scheduling strategy that enables digital signage to automatically show the right content at the right time and location.
2. A learning mechanism together with a novel couponing system that enables the system to learn automatically how well content works in certain contexts.
3. A requirements analysis, implementation and experiences from the deployment of the proposed system.

Fig. 1. Deployed MobiDiC sign (Screenshot translation: "Coupon 1. Photograph display, 2. Show Photo in store. Coupon is for free gummi bears.)

Related Work

Research prototypes of digital signage or Situated Public Displays have both been deployed in labs or in the public. Some lab deployments like BlueBoard [13] or MERBoard [16] provided shared workspaces for small groups. Other lab deployments were designed to foster continuous information exchange for small groups, like CWall [13], Plasma Poster Network [13], Notification Collage [5], MessyBoard [4] or Semi-Public Displays [6]. Other deployments like Groupcast [8] or Opinionizer [2] were designed to foster interaction between people in a semi-public space. A good survey on such systems is provided in [7].

Commercial deployments on the other hand focus on showing information and ads to large audiences. BBC's big screens[1] show TV-like information on large places, and InfoScreen[2] shows both information and ads in subway and train stations. On the technical side, professional digital signage solutions like Sony's Ziris system[3] are commercially available.

A few research prototypes have been deployed for large public audiences and are used to measure the public reaction to the prototypes. E-campus [16] is an effort to deploy displays throughout a whole university campus. Currently, mostly artistic content is shown. News & Reminder Displays [10] are also a deployment at a university to study how users can be supported in deciding whether or not to act upon shown information. The combination of digital signage and mobile devices promises to compensate for the weaknesses of both. Nichols [12] proposes to use mobile devices as a remote control for any kind of electronic devices. The Hermes Photo Display [3] shows how Bluetooth can be used to exchange photos between mobile phones and

[1] http://www.bbc.co.uk/bigscreens
[2] http://www.infoscreen.de
[3] http://www.sonybiz.net/retail/displays

public displays. Shoot & Copy [1] is a technique to take photos of a digital sign, process these with image recognition and copy the photographed content in electronic form to the mobile phone. Several commercial systems that copy coupons to the user's mobile phone already exist. Bluespot[4] provides kiosks where users can copy a coupon to their mobile phone via Bluetooth. MarketEye[5] is a device that can be attached to paper signs. Via Infrared or Bluetooth it causes the mobile phone to send a SMS that requests a coupon.
Less work has been done regarding the scheduling of content on digital signage. Storz [15] proposes a technical solution to manage the scheduling in the eCampus deployment. BluScreen [14] was the first system to use auctions to sell advertising space on digital signage, similar to Google AdSense[6].

Context Adaptive Scheduling

For scheduling the content, we propose a system similar to Google AdSense, where advertisers would pay for a certain user reaction (e.g. a coupon being redeemed) and the system would automatically schedule content (depending on the context) such that utility (for the display owner) is being maximized. For each of the possible audience reactions *j* (e.g. somebody looking at the content, interacting with it or converting a coupon), the advertiser would specify his utility u_j that somebody shows this reaction. The current measurable context of the sign can be described by a number of features $F_1 \dots F_n$. The sign senses its context with the available sensors and computes the current context feature values $f_1 \dots f_n$. The function $A_j(f_1 \dots f_n)$ is then used to predict how many people actually show behavior *j* if the content is shown.
The expected utility of showing a content item ('ad') in a given context with different possible audience reactions *j* can then be simply described as

$$EU(ad \mid f_1 \dots f_n) = \sum_{j=1}^{m} A_j(f_1 \dots f_n) u_j$$

The sign would then simply present the content with the highest utility. The central difficulty is then to determine the function $A_j(f_1 \dots f_n)$. We propose that this function can automatically be learned by observing actual audience behaviour, e.g. whether the audience converted a coupon. We use a simple Bayesian classifier to predict the number of converted coupons in a certain context from the number of converted coupons in previous similar situations.

[4] http://www.bluespot.de
[5] http://www.accinity.de
[6] http://adsense.google.com

Requirements Analysis

We decided to deploy the prototype in the only digital signage network that was available, spanning a considerable area. At public telephones throughout the city, 13" advertising signs were deployed. We used 20 of these signs to deploy the MobiDiC system (see Figure 1). In the deployment, we used coupons as the only feedback channel. The idea is simple: The customer can pick up a coupon at the sign that contains a code. This code encodes the time and location where he has seen the ad. The customer then presents the coupon at the shop and is given a rebate or promotion. The shop feeds the code back into the system. A complete history is kept on which ad is shown on which sign at what time together with the values of the context features and how many coupons were converted. This database can then easily be used to apply the proposed learning procedure to learn the function A_1.

Advertisers

We conducted a questionnaire with potential advertisers to see their requirements on such a system. We distributed the questionnaire to all shops in the important shopping streets of the city. In total 97 questionnaires were distributed. The shops were asked that the shop owner should fill in the questionnaire. Where possible, it was filled in immediately together with the shop owner. If that was not possible, the questionnaire was left in the shop to be filled in later. One and two weeks later we went to the shops again to collect the questionnaires. In total we could collect 39 questionnaires. The results are presented in table 1. Not all shops answered all questions. In these cases, we state the number of yes and no answers separately.

Table 1: Results of the Advertiser Questionnaire.

Already use Coupons	**Yes**: 23, No: 16
Main Benefits for Coupons	New Customers, Increased Sales, Measurability of Success
Interested in Digital Signage Advertising	**Yes**: 26, No: 13
Interested in Using Coupons	**Yes**: 25, No: 14
Share Feedback Data with other Advertisers	**Yes**: 23, No: 7
Select location for ad	Automatically: 5, Manually: 12, **Manually with Recommendations**: 16
Select time for ad	Automatically: 3, Manually: 11, **Manually with Recommendations**: 19
Show ad together with other advertisers	Yes: 10, No: 9, **Select certain businesses with whom not**: 14
Submit Coupon to System	**Web Form:** 13, Email: 10, Mail: 5, Scanner at Counter: 4
Limit Number of Coupons	Yes: 11, **No**: 17
Would like to use System	**Interested**: 27, Not interested: 11
Most important System features	**Measurability of Advertising Success**: 20, Optimization of Location: 17, Show Ads on Digital Signs: 16, Optimization of Time: 13, Coupons: 13

The measurability of advertising success was perceived as the most important system feature. Interestingly however, most shops disliked the automatic ad placement that we proposed and instead preferred manual placement with recommendations from the system. It is very promising that advertisers are willing to share effectiveness data of their ads so that the corpus of all ads can be optimized. Clearly, for a commercial system a constraint system would be necessary that allows advertisers to specify certain ads with which they do not like to appear on the same screen. Also, for a commercial system automatic scanning of the coupon from the mobile phone screen would be necessary. While distributing the questionnaires, we noticed that almost none of the small shops were equipped with a barcode scanner. While half of the shops had a PC with Internet connection, this was almost always placed in the back office behind the sales room. Therefore we decided for the prototype to use paper sheets where employees would manually write down the code, which shops could upload via a Web form, or could also be collected by us. It is convenient that most shops see no need to limit the number of coupons that are issued, so we do not need to care about this, which would be difficult if the user only takes a photo of the coupon. Because the measurability of advertising success was mentioned as the most important feature by the advertisers we implemented an extensive interface to view the statistics. Interestingly, after deployment of the system we found that actual advertiser behavior differed widely from these stated preferences (see Section "Experiences").

Customers

From informal prototype tests and the advertisers study, we considered an alphabetic code that is transferred from the advertising sign to the customers' mobile phone via Bluetooth, SMS or camera the best solution. We suspected that SMS would not be very popular, because each coupon possibly has a low monetary value, and forcing the customer to send a SMS for which he has to pay would further decrease this value. We decided to conduct an experiment to compare the usability of the Bluetooth mechanism versus the photo mechanism and conduct structured interviews to ask for the preferences of photo versus Bluetooth versus SMS.
In an experiment, two mechanisms to issue the coupons were compared. A mockup of the advertising sign was created using PowerPoint on a convertible tablet PC. The tablet PC was attached to a real phone pillar in the city center. On the mockup, a coupon for a belt of the value of 10€ was presented together with operating instructions. The system was not explained to the participants, instead they were asked to just read the operating instructions and get the coupon. In the photo condition, participants would have to take a photo of the sign using their own mobile phone. In the Bluetooth condition, they would have to activate Bluetooth and set it to 'visible'. A hidden wizard-of-oz would then send them the coupon via Bluetooth using a mobile phone. The participant would have to accept the incoming connection. The time needed from the first key press on the users mobile phone until the coupon was saved on the mobile phone was measured. In both conditions, participants would then go to the shop, which was approx. 60m away, and participate in the interview. They would then get a bag with the belt. A between-subjects design was used. N=24 participants were recruited from passers-by, 12 for each condition. 22 participants were interviewed.

Passers-by were asked randomly, but most of the older people rejected, resulting in participants from age 15-30 years, μ=20.9 years. 10 participants were male and 12 female; there were 11 pupils, 6 students and 5 other professions. When asked to participate in the camera condition, 5 passers-by rejected because they had no camera on their mobile phone. In the Bluetooth condition, 8 rejected because Bluetooth was not supported, 4 had security concerns and in 3 cases the Bluetooth did not work.

Except for 3 participants where Bluetooth failed, all participants could understand the operating instructions on the sign and use the system. In the photo condition, participants needed 5-25 seconds to get the coupon (μ=15.3s, σ=6.5s). In the Bluetooth condition, participants needed 5-30 seconds to get the coupon (μ=10.75s, σ=7.72s). During the experiment, most of the time 1-2 other visible Bluetooth devices were in range, which would have received the coupon unintentionally if the coupons would have been sent automatically. Several participants in the photo condition were surprised that merely taking the photo was sufficient ('Ok. What do I do now?'). Also, some participants spontaneously started copying the coupon to each other via Bluetooth. One woman refused to participate in the Bluetooth condition because she was afraid we would get her phone number.

In the interview, 21 participants stated they would use the system, and only 1 declined. On a Likert scale from 1 to 5, where 1 would mean 'do not like' and 5 would mean 'do like', the photo condition was rated with 4, Bluetooth was rated with 3.95, and an imaginary mechanism where the coupon would be transferred via SMS was rated with 2.04. Interestingly, most participants liked the mechanism best that they used in the experiment. From those who participated, 18 stated to have no security concerns regarding Bluetooth, and 4 stated to have concerns. 12 participants stated they had already seen the signs at public phones, and 10 stated they had not seen them. Many said not to pay attention to public phones because they own a mobile phone.

From the experiences of the experiment we decided to implement the photo mechanism. One reason to reject the Bluetooth mechanism is that we want customers to pull the coupon instead of pushing it to them to gain bigger user acceptance. Simply pushing the coupon to all visible Bluetooth devices could result in many users getting coupons accidentally and possibly being annoyed. Although pull-based Bluetooth mechanisms are possible, they would probably be more effort to use. The main reason to reject the SMS mechanism is the low rating in the interview and the possible costs.

We favor the photo mechanism because many mobile phones have a camera and most users have already tried this camera. Instead of being buried in a submenu like Bluetooth, the camera can usually be activated with a dedicated button on the mobile phone. We hope that we gain better user acceptance with the camera mechanism, because unlike SMS or Bluetooth it is obvious that this is a unidirectional data transfer from the sign to the mobile phone and no private data like the phone number is revealed. In addition, the process of taking a photo is a common process of making something in the environment your own. Because the user has taken the photo himself, it should feel more personal and fit better to a personal device like the mobile phone.

As we noticed in the experiment, the photo mechanism is simpler than most users expect. Therefore we point out in the instructions that the user can go directly to the shop after taking the photo. One dilemma that remains with the displays on public

phones is that the owners of mobile phones do not use public phones and the users of public phone can not use the system if they do not own a mobile phone or camera. This problem however is specific to the kind of signs used and will be overcome if users go to the public phones specifically to look for coupons.

Experiences

The described system was deployed in the city center of Münster, Germany from September 20, 2007 to September 2008. It was running on 20 public signs at 10 different locations in the city center.
Over the course of one year, 17 shops participated in the MobiDiC system. Of these shops, only 2 created their own coupons and uploaded them via the Web application. For the other shops, the coupons were designed by us. Unfortunately, the feedback loop never worked quite as intended: over one year, only 37 coupons were registered as converted. In order to make context adaptive scheduling work, much more data were needed, and for this reason, the actual scheduling used never went beyond random. It is however still interesting to look at the coupons that were converted. There was a strong preference for coupon type: One coupon (free gummi bears) was converted 17 times, and four others (free coffee, 10€ rebate on clothes, solarium and tea rebate) were converted 10, 7, 2 and 1 times, the other 12 coupons were never converted. There also was a strong preference by location: The most effective signs generated 10,6,4,4,4,3,2,2,1,1 and 1 coupons, while 9 signs generated no coupons at all. The majority of coupons (26) were photographed between 2 and 8 pm. However, we could not find any strong correlations between the kind of coupon and time, location, weather, day of week or anything similar. Additionally, we could find a strong novelty effect. In September, October and November 2007 9, 19 and 6 coupons were registered, respectively, and only 4 coupons were registered since then.

Customers

Throughout the deployment of one year, we continually asked customers and advertisers for their opinion.
Semi-structured interviews were conducted asking 26 customers for their opinion. We shortly explained the system to random passers-by and showed them the signs. 13 participants were male, 13 female. The age of participants was 16-32 years, μ=25.7. The interviews were conducted at two different days in front of signs at the main market and train station. Interview duration was 3-15 minutes.
22 participants stated that they like the system, 4 participants disliked it. 20 participants owned a mobile phone with camera, 6 did not. When asked whether they would use the system regularly, 19 said they would and 7 said they would not. 17 participants said they would tell their friends about it, and 9 said they would probably not. All 4 participants who disliked the system were male, 26-32 years old, and only one of them owned a mobile phone with camera. Only one participant stated he had seen the system before, and he had thought that it was merely a clock consisting of letters, what he considered funny (the coupon code changes every second). One participant

considered the system useless, but found it creative at least. The young participants were particularly enthusiastic about the system, and two immediately gathered their friends to show them the system. Many said they would from now on look at the signs whenever they pass them. Some even said they would go to the sign specifically to look for new coupons, and one said jokingly that she would from now on spend the entire day in front of it. Some said they would use them while they wait for the bus. Some young participants considered the coupons incredible and asked why the shops would submit them so easily. Almost all participants stated spontaneously that it was a bad idea to place the signs at public phones because people who own mobile phones ignore them. They also mentioned that the idea that they could benefit from doing something at the sign would never have occurred to them. Some participants mentioned that they had no idea that 'there are not only ads at the display but instead something useful'. Some stated that the screen content should invite more to take a photo. Almost all participants said the screens were not eye-catching enough, and suggested to surround them with paper signs. Many suggested advertising with flyers and in newspapers. Many participants immediately tried the system and all of them managed to take the photo effortlessly within a few seconds.

As we saw in the requirements analysis, it is again striking that the younger the participants, the more they liked the system. We found it very promising that so many participants liked the system. It seems important, however, that customers know about the coupons beforehand, because the screens are too small and not eye-catching enough to make somebody look at the screen. From the users we interviewed, nobody expected anything interesting at the signs, and nobody stated to look at the signs all by himself. While we observed about 15 people making phone calls at the public phones, none of them looked at the screen just in front of their eyes. In order to make the system used more, more visible signs (e.g. bigger, better angle to walking direction, better contrast) clearly are necessary. We posted paper signs around the displays, but this had no apparent effect. Additionally, a paradigm shift needs to be necessary, to make the users expect something useful at the signs. Otherwise, most users seemed to expect nothing interesting at the signs (i.e. boring advertisements, telephone book) and ignored them. In order to advertise the system, we distributed 5000 flyers in the city center. This however seemed to have had no effect in mitigating the lower visibility of the signs.

Advertisers

Although many advertisers were interested, it was pretty difficult to make them actually register on the system, create ads and submit them. Except for two shops, the actual ads were finally created and submitted by us.

Semi-structured interviews were conducted repeatedly asking all participating shops regarding their experiences, opinions, and proposals for improvement.

Despite the low response to the system, all shops were very satisfied (partially because it was free for them). All of them mentioned that the system should be advertised better, for example with flyers, labels at the shops doors or in newspapers. In the beginning, all shops believed that it would only take some time until word-of-mouth would make the system popular. However, after one year of deployment, this hope

had waned. Two shops explicitly mentioned that they plan to change their target audience towards younger people using the system. Two shops mentioned that it could be a problem if only young people use the coupons who do not become customers. One shop would like to see added services, like maps, weather forecast or emergency pharmacy locations on the signs. One shop said he would prefer a printer at the sign printing out paper based coupons. He also would like to collect the phone numbers of coupon users. Also, it was proposed to use a touch screen to stop the sign while showing a particular coupon. Asked whether it was more important to them that customers see the ad or go to the shop, one shop stated it was more important that customers see the ad, one shop considered it more important that customers come to the shop, and the rest considered both equally important. The participating shops stated that they do not like to put a lot of work into the ad, and it is ok for them if it is scheduled automatically. They stated that it is ok for them to write down the codes at the counter. It became clear however that only a small fraction of converted coupons were actually written down. One vendor for example stated that 30-40 coupons were converted at his shop, but he did not write down a single one. When we interviewed customers, some of them had also already converted coupons, but for most of them the codes were not written down.

Interestingly, advertisers' opinions before and after the deployment of the system show some striking differences. Before deployment, what advertisers were most interested in was control. They wanted to control where and when their ads were shown, wanted to upload a detailed graphic as coupon, as well as check and upload coupon codes via a web form. In addition, they were interested in detailed statistics where their ad was shown and from which signs coupons were converted. After deployment of the system, this preference changed completely. Advertisers did not care about control anymore, but only about convenience and effort. Only two advertisers used the web application at all, to upload their coupon templates. For all other advertisers, they told us on the telephone how the coupon should look like and we created it for them. They did not care about deciding where and when it was shown, and not a single coupon code was submitted via the web form. Advertisers wrote down the code on a paper form (if they did), and we collected these forms. Analogous to the automatic ad placement on the web, we experienced that after a short time, automatic scheduling was well accepted.

CONCLUSION

In this paper, we presented an approach to automatically tailor content on digital signage to the context. This approach involves a feedback loop to sense the sign's context, decide which content to show and measure the audience reaction to the content shown. A context adaptive scheduling strategy was presented that determines the optimal content for each context. To parameterize this scheduling strategy, a learning mechanism was developed that can learn how well content works in certain contexts. In order to create a corpus for this learning mechanism, we proposed to measure content effectiveness by using coupons, which customers can pick up at the signs. The requirements analysis showed that the coupons should be photographed at the signs

and should contain an alphabetic code, which encodes where and when the photo was taken. A deployment using 20 signs in a city showed the feasibility of this approach. Experiences from the deployment show that generating enough feedback data to make this approach work keeps problematic. Major hurdles are the relatively low visibility of the signs, the fact that customers ignore the signs because they expect nothing interesting, the apparently to low attractiveness of the coupons and the fact that advertisers don't record the coupon codes.

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