UniDisplay - A Research Prototype to Investigate Expectations Towards Public Display Applications

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Abstract—As public display networks become open, novel types of interaction applications emerge. In particular, we expect applications that support user-generated content to rapidly gain importance, since they provide a tangible benefit for the user in the form of digital bulletin boards, discussion platform that foster public engagement, and applications that allow for self-expression. At the same time, such applications infer several challenges: first, they need to provide suitable means for the passerby to contribute content to the application; second, mechanisms need to be employed that provide sufficient control for the display owner with regard to content moderation; and third, the users' expectations with regard to the posting procedure needs to be well understood. In this paper we present UniDisplay, a research prototype that enables users to post text and images to a public display. We report on the design and development of the application and provide early insights of the deployment in a University setting.

Fig. 1. The UniDisplay prototype: passerby can post short text messages and images to the display. The 12 most recent posts are shown on the screen.

I. INTRODUCTION

Displays are becoming ubiquitous in the form of TVs, kiosks, and projections. At the same time, an increasing number of displays support user interaction, either by means of sensing technologies (touch screens, Kinect, Leap) or by exploiting Internet connection and allowing users to interact using mobile phones or other mobile devices. In this way, displays can provide valuable and engaging user experiences for communities [1] as well as tangible benefits for display owners [2]. Examples for display applications that support this type of interaction and allow user-generated content include, but are not limited to, (a) digital bulletin boards that allow users to reach a local community by posting classified ads [3], (b) discussion boards that enable citizens to discuss topics of public interest and foster public engagement [4], and (c) applications that support ways of self-expression, similar to social networks [5]. Overall, an easy way to create an engaging UX and fit in networked public displays into the portfolio of today's ICTs [6] is to enable posting a variety of user-generated content through existing social networking services, e.g., Twitter.

As user-generated content becomes popular on public displays tensions arise between stakeholders, mainly the owner and the user. Display owners usually have clear expectations with regard to the content shown on their displays [7], [8], and as a result we need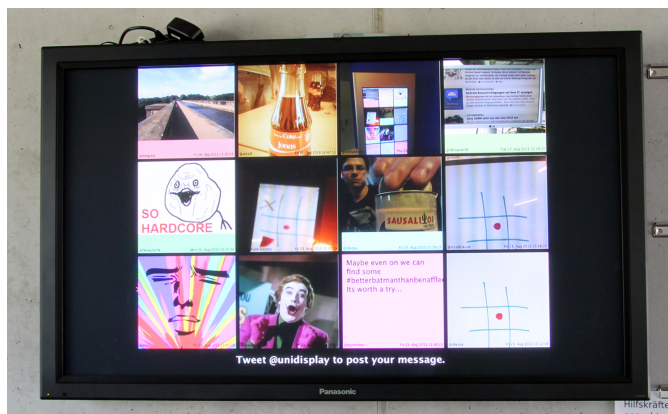 mechanisms that allow owners to stay in control of the display content (e.g., through moderation). This challenge may become even more pronounced as large display networks adapt the concept of application stores [9] and allow owners and users to select from a large variety of applications to run on displays, including applications that support user-generated content.

An obvious solution is to implement a moderation process where content is being approved. This, however, may strongly impact whether and how passerby use the application, particularly if this process is not transparent. For example, a) it may be unclear that a moderation is in progress, b) users may not know who is moderating the content, c) there may be no information when content will be shown, and d) it might not be obvious why content was rejected/not shown on the display.

In this paper we present UniDisplay – a research prototype that allows for investigating the expectations of users towards public display applications that support user-generated content [10]. The contribution of our work is threefold. We first 1) report on the results from an online questionnaire that aimed to understand the users' view on content moderation and that helped us to inform the design of UniDisplay. We then 2) report on the design and development of the application. Finally 3) we provide early insights from the deployment of the prototype in a University setting.

II. BACKGROUND AND RELATED WORK

Our work builds upon three research strands: 1) stakeholders in public display networks, 2) interaction techniques, and 3) content moderation on public displays. We briefly summarize important work and discuss how we draw from it.

A. Stakeholders in Public Display Networks

Traditional/analog public notice areas are predecessors of networked public displays. To understand how to cater to the needs of stakeholders of networked digital displays, Alt et al. [7] investigated content and practices around traditional notice boards and identified display owners, content providers, and viewers as primary stakeholders. Furthermore, they provide concrete implications for the design of digital public displays. Recently, North et al. [11] investigated tensions between the stakeholders, i.e., display owners and content providers. They were mainly interested in understanding how a research team (content providers) and four community space owners (display owners) collaborate in creating a working schedule and applications for an urban display network located in London and Nottingham. They used "tension space analysis" to show how different applications can create different goals and expectations between different partners, which can be useful when planning and creating novel applications.

B. Interaction with Public Displays

A large variety of techniques has been proposed for interaction with public displays. While much work has focussed on how to control displays using pointing devices, we are mainly interested in techniques that allow content to be created, posted on, and retrieved from the screen. Alt et al. [12] investigated interaction techniques to exchange content between a mobile phone and a digital bulletin board application running on a display. Their findings show that touch is more suitable for ad-hoc interaction when passing by a display while mobile phone based interaction is more preferred when users are on-the-go and moving. The ease of creating user-generated content through a display is also addressed by the work of Hosio et al. [4] and Memarovic et al. [5]. Both used public displays to allow users to take images and both works point out the playfulness of using them in creating user-generated content. Memarovic et al. also point out that when using public displays to create images there are some environmental issues that can create a barrier for users, e.g., strong sunlight that creates glare or awkward positioning of the camera.

C. Moderation of Public Display Content

Finally, work has been done in the area of moderation of content on public display. Alt et al. looked at how content moderation is realized in the physical world [7]. Further work focussed on how content moderation on public display can be done by the community through reporting inappropriate content [3] or by disliking a certain content group [13]. More recently Elhart et al. [14] deomostrated a post-moderation user interface for user-generated cnotent on netowrked public displays. Further ways of establishing content moderation have been presented in [15].

D. Summary

While prior work focuses on the technical feasibility of different mechanisms, we investigate user expectations. We believe that particularly pre-moderation and authentication are a central prerequisite in open pervasive display networks as they encourage display owners to allow user-generated content on their displays. Hence, we focus in the following on understanding the impact of different content moderation and authentication mechanisms.

III. ONLINE SURVEY

To inform the design of a prototype for investigating audience expectations we widely issued an online questionnaire. We investigated expectations towards authentication and moderation, focussing on people that have no previous experience with publishing user-generated content on public displays. In this way we were able to later contrast the results with actual users of public displays.

A. Method

We prepared an online questionnaire using our LimeSurvey server. The questionnaire consists of four pages. After an introduction to public displays and user-generated content on the first page, the second page asks about basic demographics and if the person ever published content on a public display or even operates one. The second page contains a number of questions regarding authentication for posting to a public display. The third page asks if participants expect their message to appear instantly, which delay is acceptable and about the content they would publish on a public display. On the fourth page we ask about their opinion towards different moderation strategies and the acceptable delay if the content is moderated. The questionnaire was available in German and English.

We distributed the questionnaire through our University's mailing list, our social network, and our research project's mailing lists. In total, 114 participants completed the questionnaire. 50 participants were female 64 are male. On average they were 24.10 years old (SD=4.54). 89 participants were students with a variety of majors including computer science, biology and medicine. 40 participants filled the English version of the questionnaire and 74 filled the German version.

B. Results

101 participants never posted content on a public display or operated one. 10 participants used research prototypes or installations in museums to post content on public displays and 7 participants operate, maintain or work with public displays. We excluded the 13 participants that had previous experience with public displays from further analysis.

1) Authentication: We asked participants to rate different authentication methods based on their personal preference (see Figure 2). With a mean of 2.72 (SD=1.26) on a 5-Point Likert scale from 1 (totally disagree) to 5 (totally agree) participants are only slightly negative towards posting a message on a public display if there was no authentication process at all. Asked about different means to authenticate directly at a display using
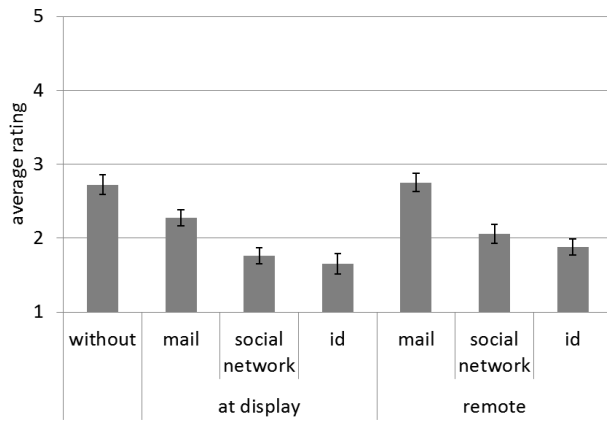
Fig. 2. Participants preference for different means to authenticate for publishing content on a public displays on a scale from 1 (totally agree) to 5 (totally disagree). Error bars show standard error.
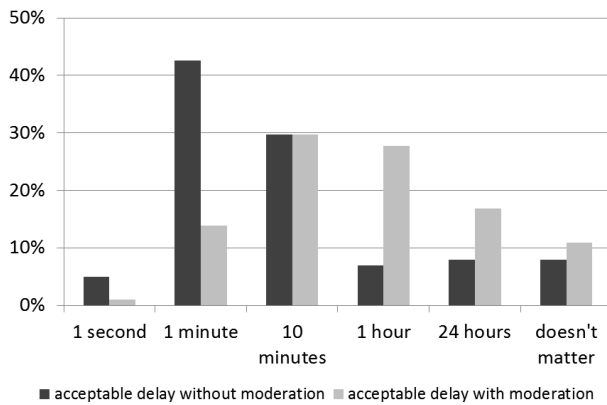

Fig. 3. The acceptable delay for messages to appear when posting messages on a public display without or with moderation.

the same scale, participants were more positive about using a confirmed e-mail address (M=2.28, SD=1.36) compared to using a social network account (M=1.76, SD=1.06) or a personal ID such as an ID card (M=1.65, SD=1.11). An analysis of variance (ANOVA) shows that the agreement with the three authentication types significantly differs (F(2, 200)=13.43, p<.001). Bonferroni corrected pairwise comparison shows that participants are significantly more positive towards using a validated e-mail address for posting content on a public display compared to the two alternatives. Asked about means to authenticate remotely (e.g. on a mobile phone, laptop) participants were again more positive about using a confirmed e-mail address (M=2.75, SD=1.40) compared to using a social network account (M=2.06, SD=1.23) or a personal ID (M=1.88, SD=1.25). An analysis of variance (ANOVA) shows that the agreement with the three authentication mechanisms significantly differs (F(2, 200)=18.06, p<.001). Bonferroni corrected pairwise comparison shows that participants are again significantly more positive towards using a validated e-mail address for posting content on a public display compared to the two alternatives.
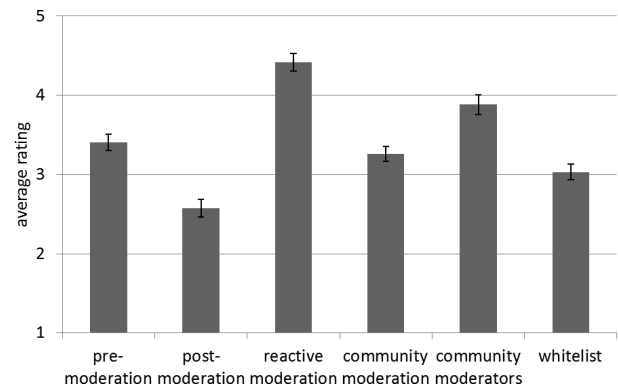

Fig. 4. Participants' ratings of different approaches for content moderation.

2) Moderation: With an average of 3.82 (SD=1.09) on the five point Likert scale most participants did agree with the statement that they expect that posted messages appear instantly on a display. Asked about the *acceptable delay* (see Figure 3) 72% stated that a delay of one to ten minutes is acceptable if there is no content moderation. If there is content moderation, participants stated that they would accept a longer delay. With 57% the majority would accept a delay between 10 minutes and one hour. 27% would accept an even longer delay. More than half of the participants strongly agree with the statement that a moderation or control process for content on public displays is necessary to avoid misuse. The average level of agreement is 4.22 (SD=1.05) on the five point Likert scale. Figure 4 shows the average level of agreement with different *strategies for content moderation*. With 4.42 (SD=0.96) the most preferred method is reactive moderation where users are able to report inappropriate or offensive content themselves. The least preferred method is post-moderation where all content is directly published but manually checked afterwards. On average, there is no strong preference among participants when asked *who should be in charge for moderating content*. Most favored is the moderation by the viewers (M=3.31, SD=1.24), followed by the space owner (M=3.13, SD=1.35), the users (M=3.09, SD=1.23), and the display owner (M=3.08, SD=1.26). Least favored is a moderation by an uninvolved third party (M=2.75, SD=1.35).

C. Discussion

The results yield two implications for the design of applications supporting user-generated content. First, there are considerable differences in the users' preference when authenticating with the display. Both in cases where posting happens directly at the display or remotely, users favor that no authentication is required. At the same time, display owners may still decide to employ authentication as such mechanisms (a) provide a barrier for users to post offensive or inappropriate content, (b) enable the display owner to get in touch with the users, and (c) allow content to be targeted. In addition, authentication is closely linked with usability. For example, posting via a social network application on the phone may be considered to be easier than via an email client.

Second, with regard to content moderation, we found no significantly different preferences among the participants. However, designers of public display applications for user-generated content that is moderated should ensure that content is being posted with no more than 10 minutes delay.

IV. PROTOTYPE

Based on the findings from the online survey, we designed and implemented UniDisplay, a web-based public display application that enables users to post short text messages and images. In this way we wanted to provide an easy-to-use, casual application that would (a) attract an as large user group as possible, (b) enable us to incorporate different authentication mechanisms, and (c) to employ different moderation strategies.

A. Application

We implemented a simple application that shows the 12 most recent posts made to the display. Posts can consist of text messages (max. 140 characters) or of a square image. As new posts arrive, old posts vanish from the screen. We do not provide any other interaction techniques for the users than posting the messages to keep the application simple and concentrate on the users' expectations. In the future we may incorporate more sophisticated interaction techniques, such as retrieving content or likes. The display client runs in a full screen browser (Figure 1). The screen layout adapts to the browser window, which allows the client to be used on displays with different resolution, aspect ratio, and orientation.

B. Authentication and Posting

To reflect the different authentication mechanisms, we implemented several ways of posting: through a simple web form; by sending an email; and by posting to a social network. A text message at the bottom explains how to post a message.

1) Web Form: A simple web form allows for posting content. The form reflects cases whithout authentication.

2) Email: Furthermore, we implemented a way to send an email to the display. The system parses the content of the email and posts it onto the display. To be able to post via email, users need to verify their address upon posting the first time. When testing, we realized that this method may infer a significant delay to the posting procedure, due to the available bandwidth and mechanisms to check for spam and viruses.

3) Social Network: Finally, to reflect cases where users authenticate via a social network, we allow users to authenticate and post via Twitter. We created a Twitter account for the display and use the streaming API which allows to listen on a Twitter user stream. To post to the display, users simply need to mention the display account name in their tweet.

C. Moderation

Each post that is sent to UniDisplay is stored on the UniDisplay server together with a timestamp and, if available, a user ID (email address, Twitter ID). Hence, we can easily exclude explicit content from being shown on the screen through post-moderation. The user ID allows us to later contact the poster, e.g., to send him the URL for an online survey.

The display client polls new posts from the database in regular time intervals. This intervals can be configured on the server thus implying an artificial delay. In this way we can simulate a moderation process. To simulate *no moderation* or *post moderation* we immediately show the content on the display. For *pre-moderation* we can set delays, reflecting the time usually required to moderate the content, for example 0 seconds for an automated moderation based on a blacklist, 30 seconds for the simulation of manual moderation, or 90 seconds for community or crowdsourcing-based moderation.

D. Implementation

UniDisplay was implemented as a client-server application. The Node.js based server stores the content posted to UniDisplay via the different channels into a MySQL database. The display client was developed with HTML, JavaScript and the template language EJS (Embedded JavaScript). Communication between server and display client is realized by means of a REST API.

To enable posting via Twitter we use the streaming API which allows to listen on a Twitter user stream. The user stream receives all tweets, retweets, and mentions of the specified Twitter user. Additionally, the user stream provides deletion notices, disconnect messages, friends lists and events such as new followers or favorite tweets. Since the user streams do not provide messages with specific hashtags we created a Twitter account for the displays. By mentioning the account name in a Twitter message ("@unidisplay") the message can be detected by the server and be posted to the display. The REST API has to be used at a restart of the application to load former messages

To enable easy administration of the display, we implemented an admin interface that shows all posts in a table. Single posts can be selected and deleted from the database. An "emergency" button is provided that allows the content of the screen to be instantly updated with new content in case inappropriate content would be posted. This feature was implemented to be able to quickly respond to requests by the owners of the places where the displays are deployed.

V. DEPLOYMENT

We deployed the web-client on five displays across the campus (see Figure 5) where it ran 24/7 for the duration of 8 weeks. Two displays were installed in the entrance area of faculty buildings and in close proximity to lecture theaters. A third display was deployed in the vicinity of a coffee kitchen shared by two research groups in one of the university building. The fourth display is deployed in a University cafeteria. The display is mounted on the wall in close proximity to tables but is visible from almost any location inside the cafeteria. The last display is located in the main canteen building of University with a throughput of several thousand people per day. The display stands at the intersection of two aisles with tables in the vicinity. Passersby for all displays were both employees of university as well as students attending lectures and courses.

Fig. 5. The five display locations with the running display client. Locations included entrance areas, cafeterias, and coffee kitchens.

Fig. 6. Data Walkthrough: All posts were printed, categorized, and annotated. Then we extracted patterns and relationships in the data.

To simulate different moderation strategies, we added an artificial delay of 0-90 seconds that was changed every 2 hours. To minimize conflicts with other stakeholders due to inappropriate content we decided to only enable posting via Twitter. Additionally, we provided several employees located in close proximity of the display access to the administration interface and hence the opportunity to delete particular posts or override the content of a display if it was spammed with offensive or inappropriate content. At the same time we asked the administrators to use the mechanism carefully and double-check with us if in doubt. During the eight week deployment there was only one occasion were we decided to override the content of the display due to inappropriate content.

A. Content

During the time of deployment, 519 messages were posted from 95 different users. To analyze the content we designed a data walkthrough. We extracted all posts from our database and printed them as they appeared on the display, including the ID of the poster as well as the timestamp. We then proceeded to review, categorize, and analyze the data to find interesting patterns and relationships (see Figure 6). 82 % of the posts were pictures. We categorized the posts into the following categories: statements, communication, advertising, self-expression, persons, display, test messages, information, offensive content, others. An analysis of the timestamps shows that most posts are made during lunch hours (12pm-2pm) and around 5pm when people usually leave the premises.

We detected a number of practices and patterns in the data that we summarize in the following:

1) Taking Over the Display Space: We observed a number of cases where people tried to take over the entire display space through subsequent posts. One strategy is to separate an image into 12 tiles and post them in a way such that they would be assembled into a large image filling the entire screen. This suggests that exclusive use of a display is of value to the users and could be exploited in the future to foster interaction with the display or to incorporate new business models.

2) Digital Honeypot Effect: Another interesting observation is that sometimes a post seems to trigger what we refer to as a digital honeypot effect. After the first post appears, other display users start to post content themselves. While the trigger is usually a controversial post (e.g., about a local soccer team), we believe that replies were often fostered by the fact that other people standing or sitting in the display vicinity realize the arrival of a new post and thus more closely observe it as they usually would if simply passing by the display.

B. Observations

During the deployment we were also able to observe some users in front of the displays and to overhear their discussions about the display and the messages. Some of them are not sure if the display really works and they discuss together if there is a moderation process going on in the background because they suspect 90 seconds to be a very long time for a message to be displayed. Often users stand in front of the displays in groups chatting with their friends while posting content via their mobile phones but some people also sit on the floor in front of the displays with their laptop to be able to post some content while watching the display.

Interestingly also people who are not in front of the displays or even never saw them start to post content because they hear or read about our displays. This effect seems to happen if there is no need to be in front of the display when posting a message and could also lead to spamming or offensive content. We did not really think of people not being in front of the display while posting because we thought that it is not attractive for them. They do not know what the display looks like and they do not know if or when their messages are shown but they post anyway. This is an effect which has to be considered when developing applications with user-generated content for public displays.

Finally, forcing people to use a twitter account for posting seems to minimize the number of inappropriate content. Some people create a twitter account just to be able to post a message and they all seem to be highly motivated to be part of the community and do not post any offensive content. In total we deleted 2 messages. We nevertheless observed critical posts. For example, some of them were created out of frustration because the display in the coffee kitchen lost the connection to the internet and did not pull new content. This is an indicator that if displays provide a benefit, they may indeed become an important artefact in people's everyday life.

C. Questionnaire

In order to learn more about the people's feelings and expectations we sent out a link to a personalized questionnaire to all display users via Twitter. We first asked the participants to enter demographic information. The tweet id, the user name and the condition were automatically tracked to be able to relate tweets and questionnaires. The participants also had to enter their user names manually as a validation criteria. In the next step we asked them about their experience regarding public displays and reasons and circumstances for using our application. They were then able to rate their overall experience with our display application and the timely appearance of the messages. In the last step we asked the participant if they think that checking messages before displaying them makes sense and if they would be willing to wait longer knowing that the content of the display is being moderated.

We had 31 mainly male participants aged between 18 and 28 which were students or employees of our University in the field of computer science. Nearly 30% interacted with a public display before using our application. All participants were also asked to rate their overall experience with the application on a 5-point-scale from poor (1) to brilliant (5). We only got ratings of 3 and above which shows that all participants mostly liked our application and only two persons would not use it again.

We then asked the participants for their reasons to post content on the displays and created some fixed categories to choose from. Those are: curiosity, communication (with friends or others), to spread news, to present an offer, promotion / advertising and other. While many participants have started interaction with the display out of curiosity, the high number of people posting more than once suggests, that they indeed saw a personal benefit in the display. Furthermore, our observations that people often posted remotely were confirmed by the questionnaire: only 65% of our participants stood in front of the display when posting their messages.

VI. Conclusion

In this paper we presented UniDisplay, a research prototype to investigate users' expectations towards public displays. We were particularly interested in authentication mechanisms, posting procedures, and the moderation process. To inform the design of our system we distributed an online survey, which was answered by 114 participants. We finally reported on the development and deployment of the research prototype

in a University setting and presented early insights. Our observations from the first eight weeks of deployment show that UniDisplay is indeed a valuable environment to study public display applications that support user-generated content.

An limitation of our research is that it was conducted in a university setting. Nevertheless, the deployment at different locations across the campus allowed us to attract a large variety of people with diverse backgrounds. All deliberately decided to interact, since we did not promote the displays.

As next steps we plan to focus on particular aspects of user expectations. We plan to compare different authentication methods, to investigate different means for posting, and to explore the impact of different moderation processes.

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