A Conceptual Architecture for Pervasive Advertising in Public Display Networks

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ABSTRACT
This paper presents a conceptual architecture for pervasive advertising on public displays. It can help researchers and practitioners to inform the design of future display networks. Due to falling hardware prices we see a strong proliferation of (public) places with displays and it is not only large outdoor advertisers anymore operating them. However, public displays currently fail to attract the attention of the user – a challenge that could be overcome by networking displays and deploying sensors that allow novel interaction techniques and engaging user experiences to be created. One major question is how to design an appropriate infrastructure that caters to the conflicting needs of the involved stakeholders. Users want interesting content and their privacy being respected, advertisers want to gather the user's data, and display owners want to be in control of the content as they fund the infrastructure. We identify the core components and discuss how control can be appropriately distributed among stakeholders by presenting three different forms of the architecture (user-centered, advertiser-centered, trusted).

Author Keywords
Pervasive Advertising, Public Display, Architecture, Network

INTRODUCTION AND BACKGROUND

With networked public displays proliferating in public space we see a new ubicomp infrastructure emerging. Public displays were so far almost exclusively used for advertising but technologies such as cameras and touch-enabled screens allow engaging (cross-display) user experiences to be created and information to be made ubiquitously available. Hence, displays can feature interactive games (potentially between remote displays) or provide personalized content.

The major factors that currently hinder the widespread adoption of applications is that putting the infrastructure into place is costly. Hence, display owners may not be apt to share public display space unless they find a way for funding. Nowadays, advertising is the prevailing business model, but further opportunities include selling applications, content, or services (e.g., songs or smartphone apps to be downloaded at the display) as well as subscriptions (e.g., a service that always shows the latest sports results or stock information as the subscriber passes by). In recent years it became clear that advertising cannot be the only use case for public displays and in order to be successful, displays need to provide a benefit for society [3]. We envision such benefits to be provided in the form of third-party content or apps which can be integrated with advertisements. Hence, commercial and philanthropic content can co-exist and be mutually beneficial.

In order for different types of ad and non-ad content to coexist on public displays, standards for (large-scale) architectures need to be provided. As a first step, Clinch *et al.* proposed an application store for public displays [4]. They argue that this could foster the development of interesting new applications. Their proposed high-level architecture serves as a promising starting point, but so far fails to anticipate the fact that in advertising environments applications and content may be provided by different entities. For example, the operator of the display architecture provides a scheduler and an application displaying content, but the content is being created by the advertiser. In addition, there is an inherent tension between the advertiser and the user. Advertisers want to gather as many data as possible in order to better target content and measure success. In contrast, the user wants to find interesting content and his privacy should to be protected.

From a research perspective, several advertising environments with customized architectures have been presented. *BluScreen* implements an agent-based architecture [9]. Haddadi *et al.* [5] presented *MobiAd*, a privacy-preserving, phone-based architecture. *CAdEt* is a context-sensitive platform with an advertising-based architecture where log files are stored on the advertiser's side [1]. None of these architectures has been deployed yet, but they provide useful hints how architectures of the future could look like. We draws from the presented concepts and extracted useful information on stakeholders and required components.

As a main contribution of this paper we present three conceptual architectures with the potential to cater to different stakeholders' needs. We identify the core components and discuss three ways how control over them could be distributed among the stakeholders (user-centered, advertiser-centered, trusted). In this way we hope to support informing the design of future, advertising-based public display environments.

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REQUIREMENTS

Nowadays, public display environments are homogenous structures where a central instance decides on the content and how it is being scheduled. In simple cases, displays show static content in a slideshow manner while more sophisticated displays may run interactive games. As displays are being networked and opened to third parties, we envision display application stores to emerge (similar to the Android Market or Apple's AppStore) where display owners can acquire apps for their display and exploit their network capabilities. Hence, a new quality and flexibility can be added to the composition of public display content and we may see new applications that share content across displays and bring together users in front of remotely located displays.

In the following we present requirements for the design of architectures for advertising on public displays. They concern the stakeholders, storing applications and content, the presentation of content, and data handling.

Stakeholders' Needs

Traditionally, display owner and content provider often used to be the same person (e.g., a retailer who deployed a display in his shop windows to advertise his products). As displays become interactive and networked, new stakeholders emerge and the boundaries between roles blur. For example, display owners may buy external content as they lack the expertise to create interactive content, developers may offer (customizable) apps, and viewers may at the same time become content providers as displays support user-generated content.

These advances make it necessary to rethink the interplay between the different stakeholders [2][4] and requires mechanisms to be installed that cater to their needs. For example, display owners may only be willing to share display space as they maintain ultimate control, app developers may want to know how often their apps have been downloaded, advertisers may want to know how successful their campaigns are, and users may want to know what happens with their data.

Applications and Content

In times when displays were not networked, content was stored on the display and being rendered by an application running on the display. As displays become networked and multiple applications may run on the display at the same time it may be beneficial to decouple content and application. In this way, content can be reused in different applications (e.g., coupons from the same advertiser), even across different displays (e.g., classified ads). Though this adds flexibility, it may well create performance issues as loading the content depends on the connectivity.

Scheduling and Presentation

A scheduler is required to run multi-display applications and to integrate multiple applications on one display. The scheduler needs to be aware of the displays' context (e.g., their location and distances in order to create a story along the trajectory of the user), the constraints of the display (e.g., an application may require a Microsoft Kinect) and which applications are available at the display. In addition, the scheduler should for each display support different forms of presentation to be configured by the display owner. Alt *et al.* [3] suggest the following types for presenting multiple content:

- In *time-multiplex* (traditional presentation model), applications are displayed after each other based on timing constraints. In this way, a public display may show a slideshow application which continuously loops through sports news, ads, and the weather forecast during the day and feature an interactive game application at night.
- In *space-multiplex* different types of applications share the display space at the same time. For example, the main part of the screen features a cross-display multi-user game whereas an app on the side of the display shows content that adapts to the user based on his preferences as he passes by (e.g., latest tweets from people he follows).
- *Integration* is a specific type of space-multiplexed presentation where advertising and non-advertising content is being interweaved (e.g., an interactive ball game, where a corporate logo is printed onto the ball).

Note that these types can be combined hierarchically. For instance, a display may, on the highest level, run in time-multiplex mode. Each time-slot can then include further time-multiplexed or space-multiplexed content.

Data Handling

As public displays are equipped with different kinds of sensors, advertisers can benefit from feedback about a campaign's success, e.g., how many users looked at the display, how many interacted, and how many took follow-up actions (e.g., redeeming a coupon). With this knowledge, the content can be refined and new business models be established that charge advertisers based on the effective exposure.

The major challenge lies in respecting the user's privacy in an appropriate way. Therefore, it is an important question where data is being stored. It can be stored local on the display client, on the user's phone, or with a trusted entity.

CONCEPTUAL ARCHITECTURE

In the following we present our conceptual architecture (see Figure 1), based on the requirements. We present the involved stakeholders before explaining the functionality and interplay of the different components.

Stakeholders

The *display owner* is the entity installing, running, and maintaining the display. Typical examples are store owners who setup a display in their shop windows or the owner of a bar who runs a display where users can vote for the next song to be played. Previous research showed that display owners often have a very clear expectation of a display's content [2] – hence mechanisms need to be provided that give display providers ultimate control as to what is shown and what not.

Often, the display owner and the *space owner*, i.e., the owner of the space where the display is installed, are the same person. However, there are cases, where this is different. One

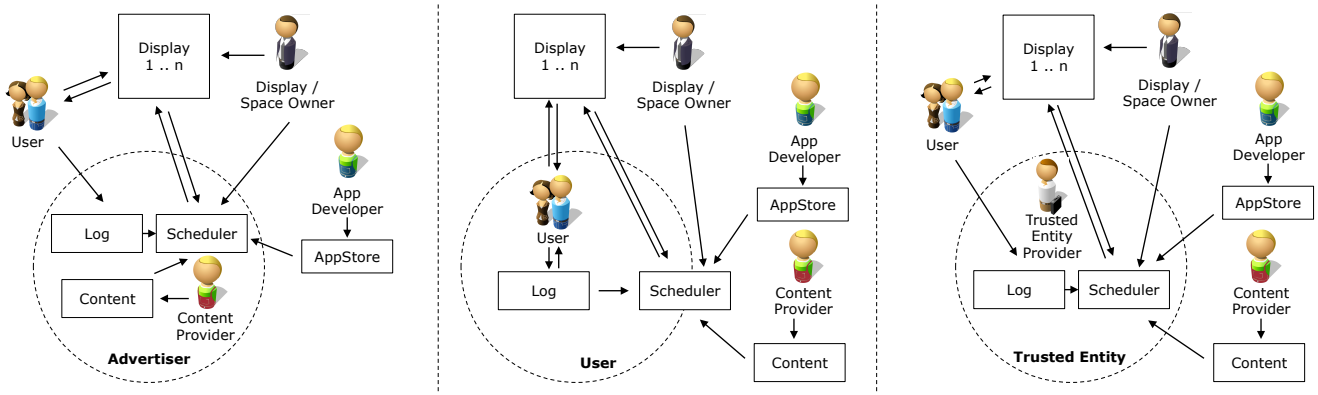

Figure 1: Conceptual Architecture Designs: advertiser-centered (left), user-centered (middle), trusted (right)

example is an outdoor advertiser (display owner) who buys a license from the city (space owner) to set up an advertising display at a bus stop or subway station. In these cases, also the view of the space owner needs to be considered.

The *application developer* provides applications running on public displays. Ways need to be provided that allow the application developer to know how often his application has been downloaded and installed in order to accordingly charge the customers (usually the display owners), e.g., per one-time fee, per usage, or for a subscription [4].

The *content provider* (e.g., an advertiser) is the entity who creates the content to be displayed, e.g., images or videos. There are cases where applications need additional content or where content is being provided by third parties.

Finally, the *user* perceives and interacts with the content on the display. He may also take the role of the content provider as he creates content himself (e.g., a classified ad).

In addition to these mandatory stakeholders, an optional *trusted entity* may be required. As we discuss later, architectures can be implemented in a way such that a trusted stakeholder controls important components in order to address the needs of different other stakeholders. For example, the trusted entity may store data about the user but only makes them available to advertisers in anonymized or abstracted form.

Components

Display Client

While traditional displays served as output devices only, sensors provide means for inputting data by allowing the display context to be determined (e.g., audience, location, etc.) and at the same time enabling the user to interact with the display (e.g., via touch or gesture input).

Scheduler

The scheduler defines what is being presented on which display and how. In order to appropriately select and coordinate content, the scheduler needs to be aware of a display's capabilities as well as of the available applications. Additionally it may require content from the log file, e.g., the ID or preferences of the user in front of the display. Different presentation modes can be implemented. The scheduler can be configured explicitly by one of the stakeholders or implicitly, e.g., based on preferences of the passer-by.

Application Store

The application store is the place where developers can offer apps to display owners. The display owner can acquire the applications that fit his needs. For example, outdoor advertisers may choose an application that shows a series of targeted ad videos based on the preferences of a user as he passes multiple displays on his way. The application store needs to inform the scheduler about the applications available for a specific display client. Additionally, a way to inform developers about the downloaded applications can be provided.

Content

With content we describe all advertising and non-advertising content that can be accessed from the applications running on the display client. If an application allows external content to be loaded, the application developer and the content provider need to agree upon how integration of the content is being realized (e.g., access via the WWW, etc.). As an application may support user-generated (and hence untrusted) content, it may be sensible to deliver content through the scheduler which can serve as a control instance or to provide means for feedback through other users (e.g., abuse button).

Log

The log stores execution and interaction data [4]. *Execution data* reflects how often an application was shown or launched and can serve as a basis for charging the display owner based on usage. *Interaction data* reflects how many users interacted with the system. This data can be used to measure the success of an application or content and possibly trigger the decision to withdraw or refine it (see also the scheduling / learning loop presented by Mueller *et al.* [7]).

Architecture Design

In the following we present different architecture designs that cater to different stakeholders' needs. The sample designs (Figure 1) are meant to illustrate the strengths and

weaknesses of different implementations. Note that all architecture can be implemented in a way that supports multiple displays with the scheduler being the coordinating entity.

Advertiser-centered Architecture

In commercial public displays where advertising is the central use case we see mainly advertiser-centered approaches. Advertisers try to gather as much information about the user as possible. These data are used both to directly adapt the content (e.g., based on gender or age) and to post-hoc analyze the success of an advertisement. As can be seen in Figure 1 (left) logging and scheduling is handled on the advertiser's side with users having neither control about their data nor about what is being shown on the displays.

User-centered Architecture

On the other end of the spectrum, user-centered architectures, as depicted in Figure 1 (middle), put the user into focus. The log file is stored safely on the user's personal device (e.g., a mobile phone) and he may even have control of what is being shown on the display as the scheduler might run on his device. The strength of this approach is that the user's privacy is well protected but he needs to be motivated to share the data with the advertiser (e.g., via coupons if he shares the history of his customer touch point encounters). A challenge of this approach can be seen in the implementation of the scheduler as in cases where no user is present a default scheduling needs to be defined by another entity such as the display owner. A use case may be displays run by public institutions (e.g., Universities or municipalities) with the aim to provide maximum value to the users.

Trusted Architecture

A hybrid solution where the user's data is safely stored but advertisers have access to relevant information would be an architecture operated by a trusted entity. This entity would keep the log files but can provide data in anonymized or even aggregated form to the advertiser. In this way the user cannot be identified but the advertiser can analyze how successful his campaign is. As the scheduler is also operated by the trusted entity, accounting for the use of applications (and possibly also content) could be centrally handled. Advertising environments of the future may be based on such architectures that consider the interests of different stakeholders. In this way public displays can show more interesting content to the viewer and hence make them more attractive while still enabling advertising as the driving business model.

DISCUSSION AND CONCLUSION

We have presented a conceptual architecture that supports advertising on public display. We see this work as an initial step in a discussion that may ultimately lead towards a reference architecture for public display networks.

Advertising on public displays is still a domain of large outdoor advertisers who have the means to put the infrastructure into place. Consequently, current display networks are strongly advertiser-centered. However, we observe nowadays that public displays are mainly ignored as passers-by do not expect to find anything interesting [8]. This effect may even get worse as logging mechanisms are put into place and users feel to be spied upon and do not know who has access to their data. Hence, we see a strong need to think about how public display architectures of the future need to look like. On one hand it is very clear that they need to support advertising as one possible business model besides others. On the other hand, ways need to be found to put the user more into the focus and unfold the potential of "symmetric communication" [6]. In this way, public displays can be made more attractive while at the same time providing ways to fund the infrastructure.

We believe that in the future large organizations may serve as trusted entities that provide the basic architecture consisting of the application store, the scheduler and the central place keeping the user data. The development of a "Display OS" may further support this vision.

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