An Application Framework for
Open Application Development and Distribution in
Pervasive Display Networks

(Short Paper)

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Abstract. Displays technology experienced a considerable progress and screens are increasingly pervasive in public spaces. Most of the display systems exist as singular non-interactive units showing static images, power point presentations or product videos. Further developments will consider the possibility of connecting the displays towards the Pervasive Display Networks. This approach will provide the background for highly interactive applications, thus creating a novel and powerful global communication medium.

The research activity proposed in this paper will consider the challenges raised by the need to support third-party application development and distribution. Consequently, the work will conceive and evaluate a web-based framework for the development, distribution and use of display-centred applications in Pervasive Display Networks.

Keywords: Display-centred applications, large scale display networks, ubiquitous computing and urban computing.

1 Introduction

The concept of Pervasive Display Networks (PDN) embodies the idea of creating large scale networks of autonomous displays that support integrated services. By removing the single management control that prevails in existing systems, PDNs should become open to content and applications from various sources and provide the ground for the emergence of a new communication medium for public places.

1.1 Motivation

A key enabler for PDNs is the ability to allow any third-parties to generate and publish applications for being consumed by displays in the network. An open model for the development of new applications is the key for the evolution of the network and its appropriation to new and unexpected uses, allowing multiple entities anywhere in a global network to become co-creators of value by developing new applications and content for themselves or for the community.

Numerous recent examples such as the Apple's App Store and Facebook demonstrate the power of enabling this model of third party applications to be easily created and deployed. Our vision is thus to move away from a world of closed display networks with content driven by advertisers and pushed to the public irrespective of their wishes to a new type of display systems, in which the respective applications may become an integral part of everyday life and a source of innovation within the communities in which they are situated [1].

1.2 Thesis

This research aims to define the set of abstractions and frameworks that may be needed to allow third-parties to generate and publish content and applications into PDNs. The topic is part of the objectives of the PD-NET project that provides the background for the proposal [2]. Globally, the thesis is going to assess the idea that PDNs can allow personalized, interactive, context-aware content for public displays to become a commodity and generate a community in which content produced by multiple entities is consumed by multiple displays.

1.3 Challenges

There are several sorts of challenges deriving from this research statement, but the most significant ones can be arranged in the following groups.

Execution environment. The concept of application is inherently linked with the concept of an execution environment. An execution environment may be defined as a collection of resources in which a task can execute, e.g., a Unix or Windows host, a J2EE environment. Within the context of displays networks and related sensors, an execution environment may also involve computational issues, such as the execution of code on the player nodes or on servers. Additionally, there is also the need to define and characterize the type of abstractions and resources that will be available to applications to represent the display network as a whole and the specific setting of each display. Specific challenges such as security and performance need also be considered to identify any particularities that are not addressed by existing solutions.

Content injection. The content generated by applications is not likely to be used individually. It will normally be consumed as a part of a broader context in which content from multiple applications is integrated into a specific display experience. Multiple content injection challenges arise from this need to support the coordinated presentation of content from multiple sources. Here, the challenges can further include scheduling, content representation and capabilities negotiation. The specific issues associated with scalability and the potential need to support substantial growth in the number of clients and updates should also be considered.

Situatedness. Situatedness is the ability of an application to adapt its behavior to the circumstances of the social setting in which it is being used. Many display-based applications may need to support this ability to sense situation and exhibit a situated behavior. Each application should have a mechanism allowing to configure and to adapt its behavior to certain local environment characteristics, users' profiles or specific usage sessions established before running. These specific issues include the

need to represent situations, the need to acquire information from social setting, i.e. people, and the need to balance this with privacy.

Application Distribution. An application store represents an application distribution platform developed for publishing third-party applications developed everywhere in a community. Applying the concept of App Store in the context of public display networks, would open display networks to new applications from a wide range of sources, but raises significant challenges given the differences between the personal mobile device market and that of public display networks.

A key difference with many implications is the existence of multiple stakeholders in public display networks. While in a personal mobile device, a single owner decides what to install, the stakeholders in a display network may include display owners, venue owners, viewers (users) and content providers (application developers). Therefore existing models, while providing an inspiring model, cannot be applied.

Support for Multi-Screen Coordination. A unique feature of open public display systems is their ability to create experiences that span across multiple displays in a coordinated fashion. It should be possible for applications to address the multiple displays in an integrated network, based for example of location or proximity criteria. This type of fine-grained coordination will need new protocols that can enable large-scale multi-screen experiences through third-party application deployment.

Interaction. Public interactive displays lack efficient and clear abstractions for incorporating interactivity. There are no widely accepted frameworks on how to integrate interaction into the content presented on displays. While creating a specific interactive solution in itself is not a major challenge, the lack of generalized interaction abstractions represents a major obstacle to the widespread adoption of interactive features in public display. A key requirement towards the emergence of interactive applications for public displays will thus be a generic solution to the issue of how to distribute an interactive application over an open network of public displays and map it to whatever interactive features may be available on each of the sites in which the application may be used.

2   Related Work

Allowing third-party application development and distribution in large scale display networks represent a new topic in the field. Its originality derives from the emerging PDN. Currently, the main research effort in this area is given by the PD-NET project, which aims to explore and establish the foundations for an innovative communication medium based on large scale networked displays [2].

The state of the art in public display networks reports about small and medium display systems developed mainly for commercial purposes such as Times Square or social entertainment and various information broadcasting, e.g., BBC Big Screens. These types of deployments are characterized by closed display networks, which operate under single and central management domain offering very often, less attracting content and supporting less user interaction.

Moving beyond these isolated display systems, important research activities have been developing since 2008, aiming to open the network and attempts for building large scale public display networks. Such installations are e-Channel system deployed in Lancaster University Campus in England [3],[4] that developed and deployed an open content distribution system for display networks and UBI-Hotspot deployed in real world urban setting in Oulu from Finland [1], which focused on delivering various services through multiple interactions modalities.

Although these research initiatives and commercial display installations aimed to open the network for multiple stakeholders, none of them offers insights to support display-based application creation and distribution by third-parties.

3   Research Design

This research is organized around four key tasks, which represent the research plan and sketch the final contributions of the thesis:

1. Investigation of technologies and design space
2. Application Model
3. Evaluate open development practices
4. Evaluate scalability

Investigation of technologies and design space. This phase was primarily conceived as an exploratory research work for uncovering the design space and identifying additional research issues. In particular, it aims to identify key properties of PDNs applications, their main design alternatives and assess the viability of web technologies in supporting a set of reference applications. The task involves extensive literature review, the creation of simple applications and the study of the development environment in existing display infrastructures, more specifically the Instant Places system at University of Minho, the e-Channel system at Lancaster and the UBI-Hotspot system at Oulu.

Application model. Once the application design space is well understood, we envision that the specification of an application model for PDN should define all the necessary protocols and guidelines for allowing anyone to create this type of applications. This task should specify an application model for PDNs and evaluate systems support for display-based applications. An Agile Methodology will be followed in which a number of relevant applications will be identified for immediate implementation and technical validation of the proposed protocols.

Evaluate open development practices. Having defined a set of development guidelines, any third-party developers will be able to create and distribute applications over the network. This task is going to validate the concept of open content creation by third-parties by promoting a community of developers. Even if this is a small community it will be composed by people who are not involved in the specifications and are mainly motivated to produce working applications. The study will aim to capture the emergence of additional requirements and study the specific development practices emerging from the community.

Evaluate Scalability. Finally, the research aims to quantify the impact of performance and scalability on the proposed application model and in particular in the observed user experience. It will aim to quantify the ability of the applications to scale in the number of client display nodes and the number of interactions per client.

4   Conclusion

So far, the research activity explored the limits of web technologies for supporting the requirements for PDNs. It was investigated different application execution environments continued by first experiments with the application models for display networks.

   This paper reports the work being conducted for addressing the challenges raised by the need to support third-party application development and distribution in PDN. As an outcome, the work will conceive and evaluate a web-based framework for the development, distribution and use of display-centred applications in PDN.

References

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