Scalability of Pervasive Displays Networks

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ABSTRACT
Large-scale pervasive public displays networks are becoming an emerging paradigm and represent a radical transformation in the way we think about information dissemination in public spaces. These networks with its pervasive nature rise a number of challenges for those who have to design, test, deploy and use them. It is imperative to understand what are the key tradeoffs in the design of pervasive displays networks, mainly on their components and respective protocols, in order to provide a fully open, global and most importantly scalable displays network.

Categories and Subject Descriptors
L.7.0 [**Ubiquitous/Pervasive/Mobile**]: Distribution and Maintenance

General Terms
Design, Performance, Simulation, Measurement

Keywords
Pervasive Displays, Application patterns, Scalability

1. INTRODUCTION
Currently, research on Pervasive Displays is mainly concerned with Human Computer Interaction [1]. Teams are focusing their studies mainly in the best way to capture people attention and in the possible interactions between people and displays. Complementary to these studies, in this paper, we intend to analyse the design of Pervasive Displays Networks. Pervasive Displays Networks are composed by displays nodes, and correspondent functional components, interconnected in an open and cooperative way, running applications that, for example, may have to be reactive to some global event. We have consider the functional architecture of a network node depicted in Figure 1, as a result of careful analysis of existent case studies [2][3]. The potentially large-scale characteristics of these kind of networks with their inherent innovative nature, characterized by a continuously changing number of users, display owners, content producers, display nodes, application items, application hosts, content types, interaction modalities, sensors and connections, may lead to several scalability and performance problems. The objective of this work is to study the main tradeoffs in the design of Pervasive Displays Networks in respect to its main core components, protocols and respective interactions, in particular with respect to the application execution pattern. We will study the main scalability issues, and their implications to the design, on application execution in different nodes, taking into account different characteristics and requirements. Existing scalability techniques will be applied to different application patterns, in particular in the web environment, in different execution contexts characterized by an augmenting number of nodes and users.

2. RESEARCH PROBLEMS
To achieve those demands, the architectural elements have to be inherently distributed and divided into multiple functional components. However, some of those components may be, in some execution patterns, more requested or have a more complex and time consuming operation, increasing systems response time. Also those components have to scale to embrace the growth of the network and to be more fault tolerant. Figure 1 presents the main functional blocks and interactions required to have a fully functional pervasive displays network, it can be instantiated in different forms and replicated as needed, depending on grows demands. This architecture relies on the Internet to have a global communication reach and it operates in a standard Web model way. It also presents a set of, what we call, critical and non critical processes, meaning that there are parts of the system that do not demand a restrict or immediate response and do not directly influence user interaction and feedback, not having the problem of compromise the users quality of experience. On the other hand, processes that have to provide an immediate response to the client are mandatorily critical, and consequently have to scale to the variety of contexts. We will focus our attention on the critical processes, those who have direct impact on user experience. In particular, inter-

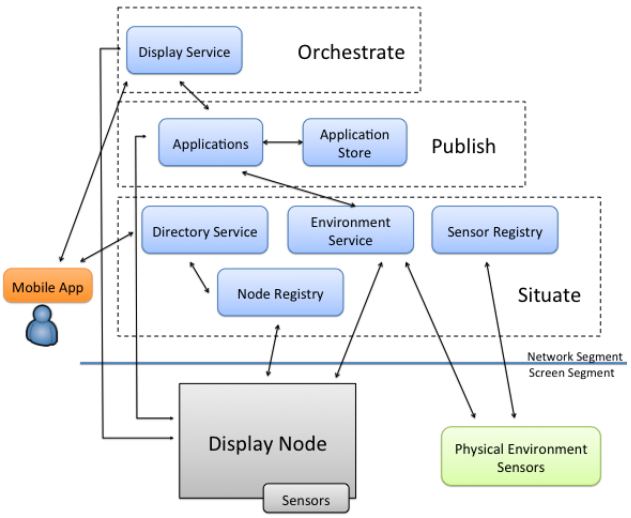

Figure 1: Pervasive Display Node architecture.

active and context-aware applications have very demanding real-time characteristics. If a node does not sense a person, adapting the application behavior at the right time, an interaction opportunity could be lost and lead to a user distrust. So, context-aware and situated applications, that had to gather information about any relevant change or interaction, have to be object of more refined studies.

Taking into account the above ideas, we will concentrate our efforts on the evaluation of scalability properties of different application execution patters, considering, for now, four application execution patterns: the standard web non-interactive application pattern, the standard web streaming application pattern, the web interactive application pattern and the global event reactive application.

In the standard web pattern, applications are executed remotely providing only the sufficient information and content to be rendered at the client node. The standard mode of operation is to send periodically a request to a server on the network, which processes the request and provides a response. Web content generation happens remotely on the server side, requiring computational resources usually located near the response server. Alternatively, applications may also provide continuously streams of data to be rendered in the clients, consuming, in this case, higher network bandwidths and processing power. Also web interactive applications react to local sensed events and finally global event reactive applications are those which react to events that may occur at other nodes in the network.

We intend to study how those application patterns will behave on this cooperative ubiquitous environment, mainly in the presence of an augmenting number of users and execution nodes. This corresponds to analyse the suitability of the above patterns considering the Pervasive Displays Networks assumptions and characteristics. Will the same web standards also apply, knowing that content and resources could be in multiple and potentially far locations? Do they scale up as the well study standard web scenarios? What will be the average response times when the number of application interactions rises or even when the sensed information floods the system? What will be the impacts on the network with the execution of multiple simultaneous applications with different rich and demanding content types or content hosts? How will different application interaction patterns or synchronization demands will affect network performance and responsiveness?

3. WORK METHODOLOGY

To accomplish these results, simulation should be used as a tool for assessing the operation of the system under various conditions, addressing the effects of the scale in the system performance. With that it is also intended to understand the main protocol properties. To do that is fundamental to model the core architecture and the core software components and build, based on simulation techniques, a testbed for testing and determining the scalability requirements for different representative scenarios of use of the network. As we have seen components are not yet defined in a restricted way. Currently, there only exists a division in functional blocks that could be rearranged in multiple physical components. The assessment of the performance of those multiple combinations will be a major key aspect in this work, trying to point out what should be the optimal distribution or in some form have a set of metrics that give the maximum threshold that does not compromise the stakeholders satisfaction. Also, as this architecture has a Web Model *modus operandi* we will deploy and assess what should be the optimal scalability techniques that better fits to solve the specific problems associated to each network components. Different approaches can be taken, peer-to-peer overlays, Web caches, content delivery networks, edge server computing or event driven models can represent a good scale technique to apply to this pervasive network at the applicational level.

4. CONCLUSIONS AND FUTURE WORK

This initial work tries to settle down some ideas, defining what should be the main functional blocks of these systems, with that, focus the work on the aspects that are important to measure and assess concerning the scalability and performance issues.

Also with this document we try to identify and anticipate the main problems that could arise with the usage and growth of the network, providing some draft problematic points to make a more profound and complete study about this pervasive network. In the future we expect to have a work proven architecture that scales and performs according the growth and the demands of this new communication medium.

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