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# Demo: Opphos – a participative light and sound show using mobile phones in crowds

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## ABSTRACT

Opphos is a mobile application that creates participative light and sound shows by using and coordinating the screens and speakers of smartphones of people in crowds. These shows are made up of waves of color and sound that are generated by the cheers and movements of the participants. Opphos is built on a peer-to-peer network middleware that provides communication between mobile phones in large crowds, where standard cellular networks would not be available or sufficient.

## Categories and Subject Descriptors

K.4.3 [Computer and society]: Organizational Impacts - *Computer-supported collaborative work*

## General Terms

Algorithms, Performance, Design, Human Factors.

## Keywords

Opportunistic network, participative, smartphones, emergent art.

## 1. INTRODUCTION

People like to gather in crowds at concerts and sports events, not only to watch the show, but also to be part of a collective and unique experience [1]. Interactive systems that support such experiences have become increasingly popular, especially systems that create crowd-sourced light shows [1]. However, as the size of a crowd increases, it becomes a technical challenge to capture and process the participants' actions and hence the level of interactivity might decrease or even disappear completely. The light show created with Mickey Mouse ears in California Disneyland<sup>1</sup> or the LED panels at the London 2012 Olympics closing ceremony<sup>2</sup> for example, are controlled by centralized systems that orchestrate the show and do not support interaction from the crowd. Because of their centralized structure, these systems require additional infrastructure (e.g., wired connections between devices, infrared emitters) and are therefore not affordable by most artists.

In this article, we present Opphos<sup>3</sup>, a mobile application that creates participative light and sound shows using the screens and speakers of smartphones in crowds, without the need for any infrastructure. We start by presenting the two modes of Opphos,

designed to support participative and unique collective experiences. Then, we explain its adaptive mediation algorithm that enhances the cheers and movements of a crowd by creating artistic waves of color and sound. Subsequently, we describe the opportunistic network that our application is built on and that ensures communication between the mobile phones even in large crowds, where standard cellular networks would not be sufficient or where they are not available. Finally, we discuss the future evaluations of Opphos at ExtremeCom and in live concerts.

## 2. PARTICIPATIVE EXPERIENCE

Tomitsch *et al.*'s study [2] reveals that, in order to support participative experiences during large-crowd events, the interactions with the system should be intuitive and should not interfere with the natural interactions of the audience. In addition, the study emphasizes the fact that the system should enhance the audience's experience and give them an impression that they are being part of something unique.

After analyzing natural interactions in live concerts and conducting informal interviews with people who regularly go to concerts and soccer games, we have defined two modes of interaction that would enhance participants' experience during such events. The first mode, called *battle mode*, is triggered when the participants start a fist pumping movement. While the phones are in this mode, their screens light up with color when the ambient noise becomes louder than a certain threshold. As we will explain in the next section, this threshold is calculated so that the phones light up only if a significantly large group of people cheer at the same time. In addition, when the cheers of a group exceed the threshold, the phones also record the color that is shown on the screens, the strength of the cheering and the sound made by the participants. The phones then pass on this information to neighboring phones in order to produce a wave of light and sound that spreads through the crowd via the screens and speakers of the phones. This mode is designed to encourage the crowd to make noise and to provide a diversion alongside the event. Typically, this mode would be used before the beginning of concerts, to heat up the ambiance, or during slow moments of sports events to motivate the athletes.

The second mode of Opphos, called *ambiance mode*, is triggered when participants sway their phones back and forth. The waves of light are created in the same way as for the battle mode, but the threshold is much lower so that new waves are constantly created by the sounds coming from the event (e.g., music coming out of speakers). In addition, the intensity of the lights increases when the phones are at the highest point of the swaying curve, creating a calm light show in rhythm with the swaying movements of the crowd. Since this mode is designed to be used during the event

<sup>1</sup> <http://www.theverge.com/2012/8/13/3239390/disney-glow-with-the-show-led-ears>

<sup>2</sup> <http://www.dezeen.com/2012/08/13/pixel-animations-at-london-2012-olympic-closing-ceremony-by-crystal-cg/>

<sup>3</sup> Opphos comes from the words "opportunistic" and "phos" (light in Greek).

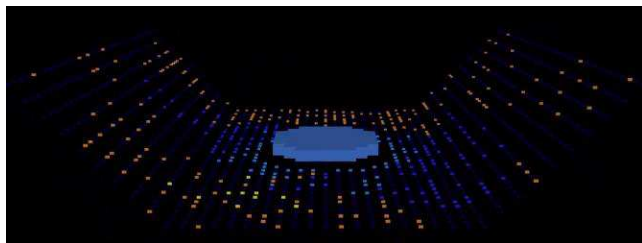
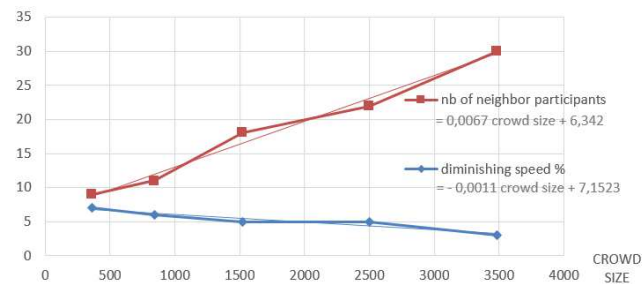
without interfering with it, the phones do not produce any sound. This mode is inspired by the swaying movements people used to do with lighters during the final song of a concert.

In summary, Opphos empowers a crowd to generate a unique show with natural interactions. We will next discuss the way it adapts to the crowds size in order to maximize the participation and enhance the light and sound effects.

### 3. ADAPTIVE MEDIATION ALGORITHM

The *battle mode* is intended to promote a competitive and collaborative mechanism. Collaborative because a significantly large group of participants has to team up in order to cheer loud enough to reach the threshold that will light up the phones. And it is competitive because the cheers that are propagated through the crowd can be perceived as a provocation by people on the other side of the audience. Hopefully, this provocation will push them to shout back and initiate a one-upmanship game. However, the *number of neighbor participants* that defines a significantly large group and the *diminishing speed* with which the strength of the light and sound of the wave decrease each time it is passed on to the next phone, (i.e., the traveling distance of the wave) need to be carefully calibrated. In particular, they need to adapt to the size of the crowd so that the effects are neither insignificant nor overpowering. In the same way, the *number of neighbor participants* and the *diminishing speed* also need to be calibrated for the *ambiance mode* in order to generate new waves constantly.

We have decided to calibrate these two parameters heuristically by simulating various sizes of crowds and varying the parameters until we reached the desired effect. In order to do this, we modeled the crowd as a multi-agent system composed of phones to adjust the parameters; we used the Netlogo [3] simulator. Figure 1 shows the data retrieved from the simulations of the *battle mode* and the linear functions that define the value of the two parameters depending on the size of the crowd.



**Figure 1. Multi-agent simulation of a stadium using Opphos. The two curves in the graph show the parameters as function of crowd size.**

Following the two modes of interaction offered by Opphos and its adaptive mediation algorithm, we now discuss the technical solutions we have found to support the information transfer between phones, as required for the application.

### 4. CONNECTING LARGE CROWDS

As it has been shown in several recent events (e.g., London Olympics, Super Bowl, Mobile World Congress), cellular networks may not scale to support the connections of large crowds [4]. To ensure connectivity without any extra infrastructure, we have therefore decided to use the PodNet peer-to-peer network middleware [5] that allows phones to connect directly to one another via Wi-Fi Direct or ad-hoc mode. Even though the opportunistic network has not yet been tested in large crowds, the high density of phones should allow rapid data transfer and support interactive crowd applications such as Opphos.

### 5. CONCLUSION AND EVALUATION

In this article, we presented Opphos, a mobile application that enables people in crowds to generate light and sound shows by collaboratively waving and shouting. This application supports two types of participative experiences: a type of one-upmanship game in which groups of participants in a crowd send waves of light and sound at each other, and a light show that synchronizes to the colors of the screens of the phones in synchrony with swaying rhythm of the crowd. In order to connect the phones, Opphos uses an opportunistic peer-to-peer network that provides rapid data transfer in large crowds without any infrastructure.

The experimentation at ExtremeCom 2013 will focus on testing the robustness of the peer-to-peer network as a technical solution to support connectivity in large crowds (i.e., extreme in terms of human and device density); we will also demonstrate the visual effects of Opphos. During the summer of 2013, we plan complementary evaluations of Opphos' emotional impact, aiming at collecting enough data to interest artists in using the app for live concerts and other crowd events.

### 6. ACKNOWLEDGMENTS

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