# Cerebro: A Platform for Opportunistic Collective Experiences

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## Abstract
While there are many existing platforms that help people plan and coordinate collective action, many serendipitous moments for group interaction are left out because we are not able recognize them. In this paper, we aim to facilitate interaction in these missed opportunities through a new form of interaction we call opportunistic collective experiences. These are short, goal-driven activities that opportunistically find participants based on their situational context and allow participants to connect with one another in a low-effort way. In order to create and run these experiences, we present a system called Cerebro, which automatically gathers and coordinates participation in experiences by detecting information about users' physical surroundings. In a preliminary study, we ran three different opportunistic collective experiences and found that they lead to interest in other participants, excitement in participating in unique locations, and increased awareness of one's surroundings.

## Author Keywords
Collective action; shared experiences; context aware; opportunistic interaction

## ACM Classification Keywords
H.5.3: Group and Organization Interfaces

## Introduction
Technology is changing the way people interact with each other. Online platforms help organize people to

**Collective action**: actions taken by two or more people in pursuit of the same collective good

**Context:** any information that can be used to characterize the situation and considered relevant to the interaction between a user and an application

**Opportunistic collective experiences:** short, goal-driven activities that opportunistically find participants based on their context

participate in collective action, or "actions taken by two or more people in pursuit of the same collective good" [5]. However, collective action requires an organizer in order for it to come to fruition, and the time required by the organizer is often prohibitively high. As a result, much collective action is never realized and people instead rely on social media to interact passively with others through sharing and consuming content independently.

Finding opportunities to engage with others, especially those physically distant, is difficult because it is hard to recognize the moments in which engagement is possible for everyone. The cost for finding these moments is high and often involves back and forth communication. In order to better recognize moments for connecting, we need technologies to both recognize people's context and coordinate available people to engage with each other.

To address these issues, we propose a new form of interaction called opportunistic collective experiences (OCEs), which are short, goal-driven activities that opportunistically find participants based on their context and allow participants to connect in a low-effort way. OCEs seek to connect people through active engagement in shared experiences, unlike social media networks, without the need for explicit planning that is required by collective action through the use of technologies to support the discovery of opportune moments and to coordinate engagement. To realize OCEs, we introduce a platform called Cerebro that can (1) describe and detect opportunities for OCEs, and (2) dynamically coordinate participation in OCEs.

To make OCEs more concrete, we present two examples. First, one OCE's goal could be to create a time-lapse of the sun setting over the ocean. The OCE looks for users with the required context for participating, in this case at a beach during sunset, and asks them to submit a photo. It will continue to ping different users and gather photos from the different phases of a sunset until the specified photo limit is reached. The photos are consolidated into a time-lapse of a full sunset for participants to view, making them aware of how many other people around the world are watching the same sunset. As a second example, another OCE's goal could be to create an American flag collage using photos from all 50 states. For blue photos, the OCE might want people who are near the ocean, in a denim store, or outdoors on a clear day to take a photo. It would also be looking in parallel for people to contribute red and white photos, such as people who are near fire stations or in snowy areas. The photos would be arranged into an American flag that shows snippets of the daily lives of people across the country, and participants would be able to identify where they fit into the collage.

The main conceptual contribution of this work is the idea of recognizing opportunities for collective engagement through the use of a computational system. Our technical contributions are techniques for (a) describing and detecting context, and (b) strategically finding and coordinating people across contexts. We exhibit the above contributions in our system Cerebro, which promotes opportune interactions among multiple people by facilitating users to opportunistically join in shared experiences across time and space.

In the rest of this paper, after reviewing related work, we present Cerebro's architecture and the specifications for defining OCEs. Next, we present our results from a preliminary user study that show OCEs lead to heightened interests in other participants, excitement in participating in unique locations, and increased awareness of one's context.

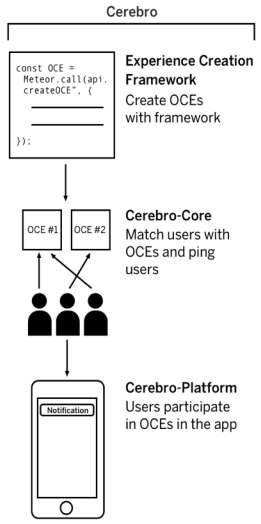


Figure 1: The three components of Cerebro

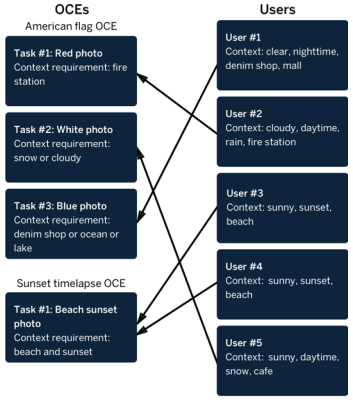


Figure 2: Matching of users to OCEs based on context

## Related Work

OCEs are first conceptualized as ideas and then programmed by a developer such that they can be run on Cerebro. There have been other efforts to use technology to help facilitate interaction such as WeDo [6], which focuses on shared-goal oriented participatory action, and Catalyst [3], which examines the gathering of critical participatory mass for different types of collective action. While these systems use technology to support human organizers in turning ideas into engagement, people still need to be managing and planning every step of the way. Once Cerebro has been given an OCE however, it does not require any human assistance in coordinating the experience.

Cerebro is able to automatically run a wide range of OCEs that are all defined using the same framework. Cerebro's architecture draws on concepts from Jabberwocky [2], a social computing stack that enables queries to effectively and programmatically recruit appropriate workers from the crowd. Similarly, Cerebro recruits appropriate participants, but while Jabberwocky only allows for programming based on the identities and relationships among people, Cerebro allows for programming based on people's context. Cerebro goes beyond looking for people based on profile-type information and can write programs that look for people at the beach during sunset or at a coffee shop in the evening.

When we talk about context in this paper, we use Abowd's definition of context as "any information that can be used to characterize the situation [and] considered relevant to the interaction between a user and an application" [1]. In particular, Cerebro focuses on describing people's context in terms of time, weather, and location.

Once Cerebro identifies a user to participate in an OCE, their participation is focused on sharing and engaging based on the environment around them. This type of participation ties to awareness systems, such as ASTRA [4], which seeks to connect users through capturing and sharing daily activities with photos, text, and digital drawings. However, while sharing through ASTRA is freeform, OCEs have a clear goal with coordinated participation. ASTRA relies on users to remember to participate, while OCEs prompt users to participate at opportune moments. Both ASTRA and Cerebro focus on in-the-moment participation. Needfinding from ASTRA highlights the importance of "support[ing] the spontaneous capture of experiences as they happen" when building connections between people.

Cerebro draws on the opportunistic nature of awareness systems, the dynamic nature of programming frameworks, and the participatory nature of collective action to enable a new form of interaction for connecting people.

## System Description

Cerebro has three main components: (1) Experience Creation Framework, a code template to write OCEs; (2) Cerebro-Core, the backend that runs and manages OCEs; and (3) Cerebro-Platform, an iOS application on which users participate in OCEs (Figure 1).

An OCE is defined using the Experience Creation Framework as a set of tasks, each of which is associated with an activity (e.g. take a photo of the ocean) and a context in which the activity can be completed (e.g. at the beach). Then the OCE is sent to Cerebro-Core to be run. Cerebro-Core finds a user who can complete a task for an OCE, and sends them a notification through the Cerebro-Platform app (Figure 2). The user then completes the task through the app and can view the in-progress results of the OCE.

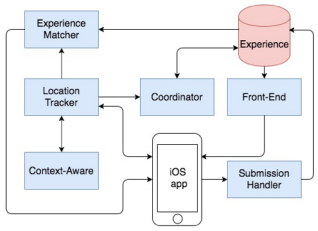


Figure 3: Architecture of Cerebro-Core

```
var storyPagePT = {
  name: "storyPage",
  contributions: {
    photo: Image,
    sentenceForNextPage: String,
    contextForNextPage: {Dropdown:
      ["hug a tree (park)",
       "sunbathe (daytime and
          clear)",
       "cloud watch (cloudy and
          daytime)",
       "people watch (coffee shop
          or restaurant)"]}
}};
```

Figure 4: Example code for a Storytime participation template

```
var storytimeOCE =
   Meteor.call("api.createOCE", {
    name: "Storytime",
    notification: "Write a story",
    teaserImage: "images/book.jpg",
    participateTemplate: "storyUI",
    resultsTemplate:"storyResultsUI",
    participationGroups:
      [participationTemplate:
      "storyPagePT", amount: 7],
    callBack: createNewPage
});
```

Figure 5: Example code for Storytime OCE definition

*Cerebro-Core*

As the component that runs and manages both the OCEs and users, Cerebro-Core opportunistically gathers user participation by finding users who are able to participate in-the-moment and automatically coordinating how different users will participate in the experience. It is a Meteor application and serves as the backend that powers a Cordova iOS application. The backend architecture is described below and shown in Figure 3.

- *Experience Data Store* holds OCEs that are either completed, in progress, or to-be-run.
- *Context-Aware* uses APIs to retrieve a set of general context descriptors for a user such as cloudy, daytime, or coffee shop. By using general descriptors, we increase our recall on matching a user to OCEs.
- *Location Tracker* keeps track of user locations.
- *Experience Matcher* determines if a user can participate in any of the active OCEs based on their context given by Context-Aware.
- *Front-End* handles loading fully customizable UIs for the OCEs. This allows Cerebro to support OCEs with a wide range of interface affordances beyond the options included in the Cerebro framework.
- *Submission Handler* updates the OCE after a user participates as specified by the OCE definition. This allows for OCEs to change dynamically based on participation.
- *Coordinator* assigns users to OCEs to maximize user participation. Additionally, it removes the user from the experience if (1) they take too long to participate and someone else can participate or (2) the user's context has changed such that they can no longer participate in the experience. Automating coordination allows the OCEs to run successfully without human intervention.

*Experience Creation Framework*

The Experience Creation Framework provides basic functionality for OCEs along with a flexible framework for designing a wider range of more complex OCEs.

To explain the Experience Creation Framework, we walk through a simplified version of the code for an OCE called Storytime that enlists users to write and illustrate a collaborative story. Storytime starts with a pre-loaded sentence and a context that matches the sentence. An example sentence is "Ominous clouds loomed overhead," with the context "cloudy and daytime". The system finds a user with that context and pings them to take a photo to illustrate the sentence, thus completing a page in the story. Then the user is prompted to write the next sentence, using one of the contexts from a dropdown. The UI for participating is shown in Figure 8. The system will then find a user with the new context and ask them to take a photo of the previous user's sentence and write the next sentence with a matching context. This continues until the specified page limit is reached. The creation of Storytime is shown in the steps below.

1. *Define participation templates*
   Participation templates define the ways a user can participate in the OCE and the type of media a user contributes. This allows Cerebro to consistently track submitted media automatically. For Storytime, the only participation template needed is for the action of adding to the story (Figure 4).
2. *Define the OCE*
   An OCE contains metadata that allows for shared UI templates and other components to be reused easily (Figure 5). An optional callback function (see step 4) determines the progression of the OCE.
3. *Define tasks*
   Each task has a participation template that defines how the user will participate and a context that

```
Meteor.call{"api.addTasks", {
   experience: "storytimeOCE",
   context: {
      name: "page" + 1
      participationTemplate:
        "storyPagePT",
      requiredContext: "cloudy and
        daytime",
      amount: 1}
});
```

Figure 6: Example code for Storytime tasks

```
var createNewPage = function(sub) {
   Meteor.call("api.addTasks", {
      experience: "storytimeOCE",
   context: {
      name: "page" + n
      participationTemplate:
        "storyPagePT",
      requiredContext:
         sub.nextContext
      amount: 1}
   });
}
```

Figure 7: Example code for Storytime callback


Figure 8: Storytime participation UI

defines what users will participate (Figure 6). Cerebro-Core handles finding users for all the tasks in an OCE.

4. *Define a callback function (optional)*
   After a user participate in an OCE, a callback let the OCE customize how the experience progresses. This enables OCEs to have future participation build on previous participation, or even have OCEs connect to each other. This enables complex dynamic coordination within and among OCEs.

*Cerebro-Platform iOS application*

When Cerebro finds an OCE for a user, the user receives a notification and is able to participate in the OCE through the app. Importantly, users can also view the results of previous OCEs they have participated in. Figure 9 shows a page from the result of a Storytime OCE.

## Preliminary Study and Evaluation

To explore how users interact with OCEs, we conducted a study to answer the following research questions:

- RQ1: How does participating in collective experiences affect one's awareness of other users?
- RQ2: How does context-awareness impact user's' participation experience?

*Setup*

The study had 12 participants (9 undergraduate students, 3 PhD students), all acquaintances in the same research lab but spread across three states at the time of the study. We ran three OCEs concurrently: (1) Storytime, creating a collaborative story by submitting photos and sentences, (2) Rainbow, creating a rainbow collage by gathering different colored photos, and (3) Thanksgiving Time, compiling photos of a predetermined set of common break activities such as waiting in the airport or going to dinner with family and friends. The study lasted for 6 days.

Post study, we conducted a 15-minute interview with each participant and examined logged data. Participants received an average of 11.7 notifications (high=29, low=2) and participated an average of 3.8 times (high=13, low=1). We have omitted 1 user from these results who received 71 notifications due to a system error and never participated.

*Results for RQ1*

Overall, users felt that seeing the results of other users was a key part of participating in the experiences. 10/12 users looked at the experience's results page after participating, and 7/12 users mentioned going back to check for additional updates. Users who were the first ones to participate in an experience found the experience less interesting, as there were no other user submissions. A user noted that the exciting part was "not necessary your picture, but just [seeing] what other people are up to". Participants also tried to guess whom the other submissions were from. Three users mentioned being able to identify local restaurants in photos and tried to guess which of their friends was most likely to be there during Thanksgiving break. After seeing a photo of Philz Coffee, a coffee chain in California, a participant mentioned that "it's one of [the two users] who's in San Francisco". OCEs not only stimulate a desire to know about other users but also demonstrate a higher value in group engagement over individual engagement.

*Results for RQ2*

Users were more excited about participating in experiences when they were at interesting or less-frequented locations, such as airports. A user mentioned he would have never thought he could participate in the airport, but since he got a notification,


Figure 9: Storytime results UI

he remembers what would otherwise have been an insignificant moment. In this case, there was a clear benefit from encouraging interaction in unexpected moments. One user described that "it feels like you're at the right place at the right time, and because you were able to contribute to something, it feels purposeful". A few users also mentioned paying closer attention to their surroundings because of OCEs, showing that OCEs increase awareness of location and situational context.

## Discussion and Future Work

We introduced the concept of programmable OCEs to facilitate shared experiences across space and time. By being context-aware and opportunistic, OCEs are able to discover opportune moments to participate in experiences. This also eliminates any explicit planning required by a human organizer and engages users directly with their present context through the experience.

A limitation of the current OCE system is the range of types of experiences it can run. Our future work seeks to advance the technical features of experiences and iterate on the design of experiences. For example, synchronous experiences in which users engage with one another at the same time would broaden the range of available OCEs and encourage the design of OCEs that focus on increasing users' feelings of awareness and connection to others.

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