CHI: G: Libero: On-the-go Crowdsourcing for Package Delivery

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INTRODUCTION

Ubiquity of mobile phone devices and ever-increasing Internet access have enabled physical crowdsourcing systems to bring great convenience to users. With a few button clicks, users can find a ride, have groceries or meals delivered, and even have their dog walked. Although services such as delivery and ride-sharing have existed for many years, technology like mobile computing has enabled these services to scale to a much broader market and larger worker population. However, there remains an untapped user potential for crowdsourcing en-route users. Many current physical crowdsourcing strategies ask the user to depart from their existing physical routine, sometimes requiring large travel distances to complete their tasks [12, 2]. And asking users to travel long distances is one of the main deterrents in existing crowdwork services, as it increases both task-completion time and cost [18].

In this paper, *we introduce and examine new model of physical tasking, on-the-go crowdsourcing, that uses people's existing routes to complete small physical tasks that are conveniently on their way*. Unlike existing physical crowdsourcing systems that need long travel distance or travel detours, on-the-go crowdsourcing requires little to no travel detour and thus focuses on making small, convenient contributions along a user's existing routes. Previous research showed that tens of thousands of people have regular mobility patterns [10] and it is theoretically possible to harness such mobility and complete tasks that require global spatio-temporal coordination and synchronization [14]. While theoretically possible, we don't yet understand nor have examples of on-the-go crowdsourcing systems.

On-the-go crowdsourcing enables people to complete numerous tasks with low effort, which can potentially motivate people and increase participation for completing tasks that would otherwise have been done by a very small subset of dedicated workers [12, 17]. For example, if someone is already at a package center to pick up their package, a small motivation may enable a low-effort task to help a neighbor who is not able to pick up their package. Students who are on their way

Every submission will be assigned their own unique DOI string to be included here.

Figure 1. Libero is a community-based peer-to-peer crowdsourcing package delivery system that uses people's existing route to help deliver packages for one another. The figure shows one of the participants delivering packages during the pilot study.

to class, cafeteria, or gym can spend a minute or less to look for their peer's lost item which might have been lost somewhere along the way. Thanks to the convenience and low effort of helping each other, we envision on-the-go crowdsourcing will increase sense of community by helping each other in neighborhoods, especially helping those in need (e.g elderly, disabilities, new moms), and benefit people who are not able to benefit from existing on-demand services, such as those in low socioeconomic status areas [18].

We explore the opportunity for this new form of physical crowdsourcing through our application, Libero, which notifies people of task opportunities as they pass by task locations. Libero is a community-based package delivery system (Figure 3) where requests for package pick-up are sent to potential helpers when they are at or near the package center.

On-the-go crowdsourcing is a new form of physical crowdsourcing which uses people's existing route and deals with uncertainty of future routes and potential helpers' likelihood of accepting tasks. In the current model of physical crowdsourcing, task notification is considered crucial for completing tasks and workers either choose tasks from a list (pull-based) or tasks are routed to workers (push-based). The pull-based approach is difficult to guarantee that potential helpers will check the task list at or near a task location [6]. In the push-based approach workers are dedicated workers, and they mostly have to accept tasks when the tasks are routed to them. But when tasks are routed to people in on-the-go settings, they are not dedicated workers and may not accept the tasks. In the current physical crowdsourcing setting, workers are expected to plan a route or reroute based on the requests, and timing of the task notification is less of an issue for workers. But in the on-the-go setting, timing of the task notification is critical because on-the-go helpers are not expected to take detours or travel long distance. Thus they are inherently motivated to help purely by convenience.

Due to such constraint, one of the core challenges in designing on-the-go crowdsourcing systems is the trade-off between ensuring high task completion rate and reaching out to larger groups of potential helpers. First, it is not trivial to identify those likely to help, because it requires the system to understand a potential helper's current context and daily routine. Second, while task notifications will make task opportunities more visible to on-the-go helpers, notifications may be disruptive to those who cannot help. To better understand the trade-off, we introduce and examine two notification techniques, *in-context* and *just-in-time* notifications. In-context notification analyzes user context, such as whether or not a helper entered a package center. Just-in-time notification analyzes proximity and timing, such as notifying helpers who are a certain distance away from the package center.

This paper makes the following contributions:

- We introduce the on-the-go crowdsourcing system Libero, which utilizes people's existing routes to deliver packages.
- We identify motivations such as reciprocity, community-building, and social obligation in on-the-go crowdsourcing systems through two pilot studies.
- We study notification techniques — just-in-time and in-context — to understand the trade-off between achieving higher task completion rates and reaching a large crowd of potential helpers.
- We identify and report on-the-go specific situational factors affecting participation, detour distance, backtracking, and hand-availability, which are not prominent in existing mobile crowdsourcing systems.

RELATED WORK

On-the-go crowdsourcing draws inspiration from previous theoretical work that aims to use people's existing routes, and thus reduces travel distance and increases convenience, to complete physical tasks. Sadilek, Krumm, and Horvitz introduced Crowdphysics and conducted an empirical study with geo-tagged tweets to show the possibility of completing tasks that require global spatio-temporal coordination and synchronization with certain digression and wait time [14]. TRACCS introduces ways to recommend a sequence of tasks to each worker, taking into account their expected location trajectory over a wider time horizon and minimizes the additional detours [6]. While theoretically possible, we don't yet understand nor have examples of on-the-go crowdsourcing systems. In this paper, we seek to understand how to design a system that taps into underused mobile resources to complete physical tasks.

There are many physical crowdsourcing systems used for different purposes, such as reporting local events [2], supporting runners and collecting marathon data [9, 7], providing transportation (e.g. Uber and Lyft), running errands (e.g. TaskRabbit), but many of them engage people outside of their existing mobility and many of them require significant travel distance and detours. Previous research showed that travel distance is one of the main deterrents in existing on-demand services [18] and people prefer to complete tasks that are at a convenient location for them [17]. Mushtag et al. showed that the average travel distance in the existing platform was 12.62 miles [12], and such a long travel distance not only causes a participation inequality problem where most of the works were done by small subset of super agents [12], it increases cost associated with tasks [18]. Although there are some systems that use people's existing mobility to passively collect data [8, 3, 1] or opportunistically collect user inputs [20, 19], our work seeks to expand the domain from passive opportunistic data collection to physical tasking.

Timebanking is one of the successful examples of exchanging untapped services and goods with motivators such as altruism, community building, and improving neighborhoods [15]. To date there are around 300 time banks in the U.S and 300 in U.K as well as a significant presence in other countries [5]. However, timebanking suffers from inconvenience of task location [16] and long task completion time [11]. As Bellotti et al. suggest the need of real-time, location-based, and context-sensitive interactions to enrich current timebanking systems [4], we believe that techniques and designs used in on-the-go crowdsourcing systems can benefit not only existing sharing economy models, but also peer-to-peer non-profit exchange systems like timebanking.

LIBERO: PEER-TO-PEER PACKAGE DELIVERY

In many cases, at the U.S universities, students living in dormitories have to go to a centralized package center to pick up their packages. Students may be busy to go to the package center to pick up their packages during the business hour and drop if off at their dormitories. At the same time, depending on the urgency and their desire, some students take their time to go to the package center to pick up their own package. In this section, we introduce Libero, an on-the-go crowdsourcing package delivery application to alleviate such problems.

System description

Libero is a peer-to-peer package delivery system that collects package delivery requests and routes them to potential helpers. The app collects a tracking number and the package recipient's name, and assists potential helpers to deliver packages on-the-go by sending notifications when they are nearby or in a package center. We describe below how to request and deliver a package, and discuss how our design supports package requesting and improves willingness to help.

Requesting package delivery

Our target users, also referred to as requesters, are people who are not able to go to the package center to pick up their own

Figure 2. To request a package pick up, the participants can simply forward the email that they received from the package center to Libero.

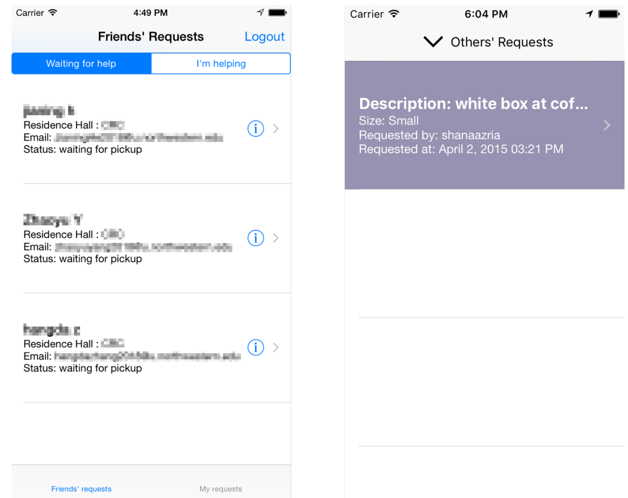

Figure 3. We used two different interfaces for pilot studies (left) and notification technique experiment (right). Based on feedback from our pilot studies, we included the size of the package in the list so that helpers can get a sense of whether or not they can help.

packages. Since users receive package notifications from the package center through their email (Figure 2), we decided to follow this pattern and allow requesters to forward the email to us if they want to request that their package be picked up. The requesters can see delivery status of the package and the deliverer's name. The email forwarding design draws inspiration from an itinerary planning system, TripIt, which aggregates confirmation emails and automatically transforms them to a master itinerary. The requesters can also call the deliverer in case there is a need to communicate as well as chat using the in-app chat function. The requesters can also cancel the request if they decide to pick up their own packages (e.g. they waited a couple of days but no one helped, or they happened to pass by the package center and picked it up on their own).

Delivering packages

Our potential helper are people who pass by the package center or users who are going there to pick up their own packages. Helpers receive package request notifications of people living in the same dormitory. If the helper decides to pick up the package, she is redirected to "Friends' requests" in two pilot studies (Figure 3 left), and to the "Others' Requests" in the notification technique experiment (Figure 3 right). This page shows a list of all the packages waiting for pickup sorted by chronological order of time and date of request. To pick up a package, the deliverer selects the package she wants to pickup and, after confirming the pickup, is provided with the image of the requester's package notification email. The helper can then show the email to the clerk authorizing him to receive the other student's package. As this occurs, the requester whose package was just picked up, receives an email and an in-app notification updating him of the status of his request, revealing the deliverer's name as well as the date and time of pickup.

Just-in-time and In-context Notification Techniques

We introduce two notification techniques, just-in-time notification and in-context notification, in order to understand when helpers are more willing to pick up tasks. Just-in-time notifications try to capture all the opportunities of people who might be willing to help and notify any user who passes by the task location. People receive notifications as they are passing nearby package center.

On the other hand, the in-context notification designed to consider the contextual information of users, such as their direction of travel, whether or not people are at the task location, and sends notifications sparingly. In this study, we design in-context notification monitors the distance from the users' location to the package center and only pings the user when she is entering the package center.

USER STUDIES

Pilot studies: Understanding user motivations

Set up

We conducted two pilot studies mainly to understand socio-technical factors such as motivations surrounding community-based physical tasking, in situations where money is not the primary motivator. We used just-in-time notification for both pilot studies since we try to maximize the task opportunities.

Groups of three and seven undergraduate students were recruited for the first and second pilot study, respectively. We sent out a study flyer to convenient samples via email and used snowball sampling approach to recruit other participants who were living in the same dormitory. All of three participants who participated in first study wanted to join the second study as well. In the second study, four students were in one residence hall, and the other three were in another residence hall. We recruited a group of students from each residence hall so that those students could help each other without having trouble accessing the building when they are delivering packages. After the study, we conducted a semi-structured interview to ask about their experience and motivations in using the system. The study lasted for a week and students received $15 gift card as compensation.

Results

In total, 15 package pick-ups were requested and 7 packages were delivered in the first study, while 14 pick-ups were requested and 8 packages were delivered in the second study. Unlike main drivers for participating in existing mobile crowdsourcing platforms, which are monetary compensation, control over schedules, and task selection [17], we identified three main motivators, namely reciprocity, community building, and social obligation, in helping others in on-the-go crowdsourcing system.

Reciprocity. From both studies, we found evidence of reciprocal behavior in that everyone who was helped later helped someone else in return. For instance, during the first study, P2 did not help any others, but in the second study she picked up seven packages for P3. One participant who called herself a lazy user said: "I was helped too often, so I felt obliged to help my friends in return at least once in a while."There also exist users like P1 in the first study who are more willing to help others with packages.

Community building. Our participants helped others because they could see their friends who would otherwise not have been able to meet due to the study overload. P1 said that *"I help others because I can meet my friends who I haven't seen for a while since new quarter began"*. They also mention that this might create an opportunity to meet new people in the community if there are more people involved in the studies.

Social obligation. Interestingly, another reason that they helped others was because they felt bad for only picking up their own packages when they already knew that their friends had packages. Therefore, in the second pilot study, we tweaked a notification message from "Can you pick up a package for [package recipient's name]?" to "Hi [potential helper name]! can you pick up a package for me? –[package recipient's name]. And indeed it affected potential helper as P4 stated: "I felt moral obligation that I should pick the package up for the package recipient after seeing the notification message".

Notification Techniques Experiment

Set up

We conducted a two-week long, within-subjects experiment in order to 1) evaluate how the notification techniques affect task completion and cost of disruption, and 2) understand when helpers are more willing to help and what are situational factors influence their helping behavior. In-Context (IC) notifications notify users when they enter the task location while Just-in-time notifications (JIT) notify users when they are within the greater region that the task location is in. To implement in-context notification, we placed bluetooth enabled low energy device with the broadcasting signal power of 4dB and 1200ms as the interval. To implement just-in-time notification, we used geo-fence technique with 100 meters as a radius.

We recruited 16 people from local university mailing lists, the average age was 25 (sd=3) with 9 male and 6 female participants. They were randomly assigned to one condition and asked to switch to another condition from the setting page after one week. The order of conditions for each person was fully randomized.

In both conditions, the participants were asked to deliver packages from a specified pick-up location to drop-off location if they receive a pick-up request notifications and are willing and able to do so at the time. We set up the pick-up location on the route from the nearest train station to our engineering building, and the drop-off location at a building adjacent to the engineering building. We tried to simulate the real-world situation as close as possible in designing the task location route, to ensure that the participants frequently pass through the pick-up location and they do not have to deviate much from their route when they go to the drop-off location.

One of the authors served as requesters during the experiment. In this experiment, we were not focused on how package size affect the willingness to help so we only requested small packages that are easier to carry than large bulky items.

After the experiment, the participants were asked to rate statements related to the perceived cost of disruption, the relation between travel distance and their willingness to help on a 5-point likert scale. The study lasted for two weeks and the participants received $25 gift card as compensation. We also interviewed 4 out of 5 participants who have delivered packages at least once in order to better understand what were the factors affecting their willingness to pick up.

How effective and efficient the notifications were?

In total, 5 people picked up packages at least once, 8 pick-ups in in-context (IC) condition and 5 pick-ups in just-in-time (JIT) condition. A total of 19 notifications were sent in IC condition while 81 were sent to the just-in-time notification users.

The helpers in in-context group had higher task pick up rate than that of just-in-time group. We found that there is a significant difference ($t(20) = 2.79$, $p = 0.001$) in pick-up rate between IC ($\mu = 45.24\%$, $\sigma = 45.86\%$) and JIT ($\mu = 7.13\%$, $\sigma = 14.78\%$). However, there is no significant difference ($t(28) = 0.66$, $p = 0.51$) between the mean number of pick-ups between IC ($\mu = 0.53$, $\sigma = 0.99$) and JIT ($\mu = 0.33$, $\sigma = 0.62$).

We analyzed the number of notification ignored for measuring cost of disruption, and we found that there is a significant difference in the number of notifications being dismissed between IC ($\mu = 0.4$, $\sigma = 0.91$) and JIT ($\mu = 3.6$, $\sigma = 3.64$). However, in contrast to the log data analysis, the post-study survey data shows that the notifications were not that disruptive. The average response for the question "The app notifications (alerts) were disruptive" in 5-point likert scale was 2.31 (σ: 1.08) in JIT and 1.81 (σ: 0.75) in IC condition. Our assumption is that, given the fact that people receive 65.3 notifications per day [13], the amount of notifications received in either conditions didn't feel disruptive at all.

What are the situational factors in on-the-go crowdsourcing?

Hands Availability. One of the main reasons that didn't pick up the packages was that they couldn't carry the package. P14 mentioned that he had to bring both his lunchbox and coffee so he couldn't deliver the package. P12 also said that "I did not have hands to carry [so I didn't pick up]. Also one time, I had to put a package in my backpack...".

Personal situation. Their schedule and mood also affected their willingness to pick up. Sometimes they are in a hurry or they just didn't feel like doing it. P5: "It also depends on my schedule and mood; if I have a meeting with my advisor and get nervous, I wouldn't pick up even if I am there; If there is something important or you are nervous, you don't care about other things". Also, it depended on their next destination, e.g. if they are on their way back home, they are less like to pick up packages because either their home is not near the drop-off location, or they had a long day didn't wanna do anymore helping. As P12 said: "I was on my way back home, so didn't pick up".

Missing the right moment and having to walk back. Participants also mentioned that they missed the notifications or checked the notifications too late and didn't want to walk back and pick up packages. P12: "sometimes I couldn't feel the notification, and sometimes I checked the notification after passed the coffee lab, then..I was like oh well... and I kept walking."

DISCUSSION AND FUTURE WORK

In this paper, we introduced peer-to-peer on-the-go crowdsourcing package delivery system Libero that uses people's existing routes to deliver packages. We conducted two pilot studies to identified motivators, namely reciprocity, community-building, and social obligation, for helping in on-the-go crowdsourcing where monetary reward was not primary motivation. We also introduced two notification techniques, just-in-time and in-context notification, which are at the two ends of spectrum in user recruitment, in order to explore the trade-off between task completion rate and cost of disruption.

Our findings showed that in-context notification yielded higher acceptance rate than just-in-time notification, and perceived cost of disruption was lower in in-context notification than just-in-time notification. Having a stricter context matching in the notification technique sends less notifications to the crowds and thus lower the cost of disruption, which becomes be higher if the context matching is too loose. However, if the context matching is too strict, it might overburden the small subset of the crowds, or miss the opportunities to notify other people who might have been willing to accept the task. In the future, we would like to explore task routing techniques that take into account pick-up demands, task urgency, as well as potential helper's routes and likelihood of help to route tasks to potential helpers.

Our results also showed that factors such as hands availability and having to walk back are distinguished from situational factors on mobile crowdsourcing services [17]. For on-the-go crowdsourcing systems that require helpers to deliver goods should be aware of potential helpers' hands availability. We should also design the notification technique carefully so as to prevent helpers from checking notifications after they passed the task location. We are currently working on techniques that start fine-grained monitoring as a user enters a large region of interest, and notify users ahead of time based on factors such as mobile phone usage behavior and walking rate to fine-tune notification opening location is almost at the task location.

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