Contributing During the Commute: Why Transit Riders Submit Information About Bus Stops with StopInfo

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ABSTRACT
A key issue for systems that rely on community contributed, updated, and verified information is motivating and sustaining participation. We investigate this issue in the context of civic, geographically-situated information systems. We focus on StopInfo, a system that provides detailed information about transit stops, primarily oriented toward blind and low vision riders. StopInfo augments transit agency data with information contributed by community members. To investigate community members' motivations for contributing such information, we draw upon Value Sensitive Design theory and methodology. We find that transit riders are primarily motivated to contribute in order to help others in the community, where particularly helping blind or low vision riders also mattered to some contributors. Finally, we discuss how a request mechanism for StopInfo could help support values for contributors by allowing them to directly fulfill a need for a member of the community, as well as provide a way for blind and low vision riders to ask for help without bringing explicit attention to their disability.

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H.5 Information Interfaces and Presentation: User Interfaces; K.4.2 Computers and Society: Social Issues—*Assistive technologies for persons with disabilities*

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Public transit, accessibility, visual impairments, community-sourcing, crowdsourcing, human values, motivation, Value Sensitive Design

INTRODUCTION

Enabling easy and efficient travel is the goal of many current transit information technologies. Examples of information that these systems provide include directions from one place to another[1], current traffic conditions[2], public transit arrival and departure times[3], and wait time at the airport[4]. Additionally, since technologies such as smartphones have become more ubiquitous, several applications are now drawing on contributions from travelers using these apps on-the-go to collect information that is localized, descriptive, and up-to-date [16]. However, ensuring that these benefits continue means that information contributions must not only be accurate, but sustainable. This requires ongoing participation from the community, whose motivations for contributing are diverse and may wane over time [22].

We investigate this issue in the context of civic, geographically-situated information systems, specifically a transit information system called StopInfo. StopInfo provides detailed information about bus stops with the goal of helping public transit riders, particularly those who are blind and low vision, find and verify bus stop locations. Prior evaluation of StopInfo showed that it supports the independence of blind and low vision transit riders, who among other things reported taking transit trips that they would not usually have attempted without the tool [5]. The information was also useful for wayfinding both to and from the bus stop. Increased accessibility of fixed route buses offers more options and flexibility for blind and low vision riders, and could potentially have health benefits as well, offering an easy opportunity for walking exercise by making alternate stops easier to locate.

The information presented in StopInfo comes from a transit agency in the Seattle area, King County Metro (KCM), augmented with information that is entered by the community, primarily as individuals wait at transit stops. In its first year of deployment, StopInfo received 1879 user submissions about 1148 unique bus stops in the Seattle area. Due in part to a number of press releases and community outreach events, participation has been relatively well sustained for the first year of deployment. However, as might be expected, the number of new submissions has begun to decline (Figure 1). To ensure information is accurate and up-to-date, it is important for StopInfo to support contributors' motivations for continuing to enter information in order to help encourage increased or long term participation [29].

Toward this end, we employed theory and methodology from Value Sensitive Design [12] to elicit and understand the values and motivations associated with contributing information

[1] http://maps.google.com
[2] http://waze.com
[3] http://onebusaway.org
[4] http://gomiflight.com/

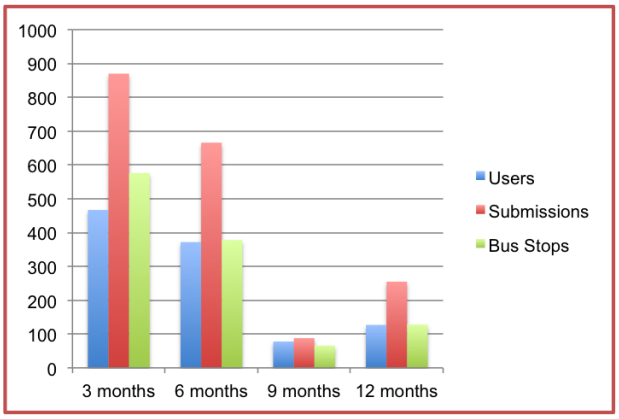

Figure 1. Submission numbers for StopInfo over the first twelve months of deployment. The chart shows the new users (determined by a unique ID), information submissions, and bus stops for each three-month period. A major press release occurred five months into deployment, and outreach events for StopInfo were conducted ten months into deployment.

about bus stops to StopInfo. In particular, we conducted a survey with previous contributors to the StopInfo system and also recruited non-contributors (i.e., people who had not contributed to StopInfo before and may or may not be willing to contribute in the future), followed by additional semi-structured interviews with some of these individuals. These survey and interview results then inform the further evolution of the system to help maintain the level of contributions from current StopInfo contributors as well as to encourage others to participate.

THE STOPINFO SYSTEM

OneBusAway. StopInfo is a web-based application that has been incorporated into OneBusAway [10, 32], a set of tools that provide real-time arrival predictions and other transit information, such as where bus stops are located on a map and which stops are traversed by a particular route. OneBusAway builds on the work of Dan Dailey and others on real-time transit information systems, such as MyBus and BusView [19], and has been widely adopted in the Puget Sound region, used by over 100,000 unique transit riders each week. The system is freely available as an application on the iOS, Android, and Windows Phone platforms, and also via SMS and the Web. Research on OneBusAway has surfaced several significant benefits, including increased or greatly increased satisfaction with public transit for 92% of survey respondents, increased feelings of safety for some (particularly while waiting at night), and decreased wait time at the stop [33]. In order to make these benefits available to as many people as possible, there has been significant attention devoted to ensuring that the apps, in particular the iOS app, provide adequate accessibility.

The original StopInfo was integrated with OneBusAway on iOS for a number of reasons. First, OneBusAway is already well adopted by people, and many check the application from their smartphones while waiting at bus stops. This enabled leveraging a large existing user base by allowing the community to enter information for the stop as they wait. Secondly, the OneBusAway iOS application is also heavily used by members of the blind, low vision, and deaf-blind communities in the greater Seattle region who use and rely on public transit, and has been developed and tested to remain accessible to this community. Finally, StopInfo is a natural extension of OneBusAway, and can also be useful to the general population of transit riders [5]. It includes relevant information such as how well-lit a stop is at night, which has safety implications, and whether a stop is closed.

StopInfo was integrated with OneBusAway iOS by placing an info button next to the stop's name on its details page (Figure 2) The button also has a label (similar to alt text for images on the Web) that is read by Apple's VoiceOver screen reader as "About This Stop." Tapping on the button brings up StopInfo as an integrated web view within the application, and is also accessible to blind and low vision users through VoiceOver.

Why Community Sourcing? It would be possible for StopInfo to use only the data available from the transit agency about their stops, since the information received from KCM includes useful fields such as the stop position and sign type. However, several categories of information were identified in prior work [2, 15] as useful to blind and low vision bus riders which were absent from the KCM data. These include details such as the presence of benches, bus sign position relative to the curb, and shelter orientation and placement. By having community members enter information, one can also flexibly add new categories as needed. For example, current work focuses on information for blind and low vision riders, but it would be straightforward to add additional fields useful for wheelchair users and others with mobility impairments.

In addition, since the OneBusAway application is popular, presenting riders with the opportunity to contribute while checking bus times and already waiting for a few minutes before boarding their bus seemed a natural extension of the application. Further, the information that StopInfo collects is simple to determine (for example, whether there is a trash can or not). We discuss the time and cognitive effort to submit information further in a later section.

Finally, there are also benefits for those who contribute information. In particular, it gives transit riders a sense of ownership of the quality of the information, and a direct hand in improving public transit in their community. Riders have frequently complained about inaccuracies in the real-time data provided by transit agencies in OneBusAway [11]; many have expressed the desire to be able to fix these inaccuracies so that other riders might have a less frustrating experience, and potentially avoid missing the bus.

At the same time, there is a cost for including community sourced information, namely the potential for inaccurate information and misuse. To date, our mechanisms for verifying information and for disincentivizing spamming and filling in false information have been adequate to avoid this issue. However, it remains to be seen whether this still holds as the application becomes more widely used.

StopInfo Interface. When users access StopInfo they are presented with a text list of the stop features. An asterisk

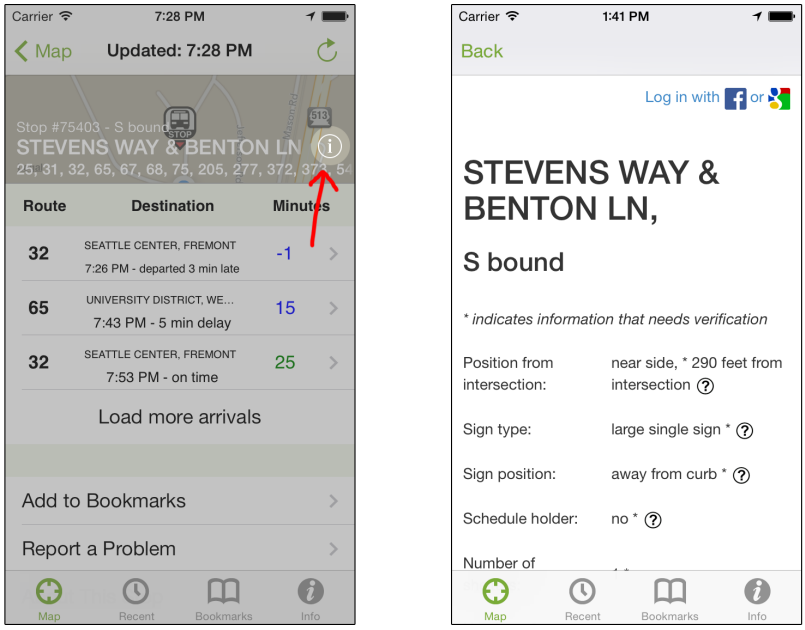

Figure 2. (left) The stop details screen in OneBusAway. StopInfo can be accessed through the info button next to the title. (right) The StopInfo view and associated information for the specified stop. An asterisk next to a field means that information has not yet been verified by three or more people. If no information exists for a particular field, we do not display it. Both screens were also tested extensively for accessibility using VoiceOver.

next to a feature indicates that the information still needs verification, meaning that it has fewer than three votes or the agreement percentage of the votes is less than 75%.

Below the list of stop information are links to add or verify information, report a stop closure, or access some frequently asked questions. In the top right corner of the screen, there is an option to sign in with an existing Facebook or Google account.

During the first five months of deployment, we encouraged contributions by introducing a reputation system that allows users who are signed in to earn points and badges by entering stop information. They can also make it onto a "top contributors" list if they choose to display their profile publicly and if they are among the top ten users with the most points. For three months, we also offered the top information contributors free bus passes provided by KCM.

Accuracy and Completeness of StopInfo Information. An initial audit three months into the deployment of StopInfo found that the information submitted by contributors was largely accurate for most categories; those which were found less accurate were due to ambiguities that have since been improved [5]. In this project we have also been manually monitoring submissions for malicious or gaming behaviors, and have not detected any as of yet.

Regarding the completeness of information gathered, out of the 8,481 total bus stops in our system, we have basic information (the position of stop relative to the intersection, the number of shelters, and the type of sign) for all of them, since it was provided by KCM. Additionally, StopInfo contributors have added information for categories not provided by the transit agency (such as position of the sign relative to the curb, number of benches and trash cans, and lighting) for 1,148 stops (or 13.5% of the total stops covered by KCM). Each of these stops received one to two submissions on average (of course, some have many more submissions depending on how frequently that stop is accessed). While happy with that number, we believe we can do better in terms of breadth by extending access and awareness of StopInfo to certain areas, or incentivizing people to contribute to stops they do not normally frequent. Currently the information submissions are heavily focused in the downtown and University areas, but many others could benefit from having this information available, notably locations relevant to blind and low vision users such as the Lighthouse for the Blind[5]. Possible incentives for encouraging breadth will be discussed in a later section.

VALUE SENSITIVE DESIGN

Much of our research is ultimately motivated by seeking to better support certain human values such as independence, safety, equity, participation, respect, and community. To approach these value questions, we employ Value Sensitive Design [12], a principled, systematic approach to the consideration of human values in the design of information technology. The primary features of Value Sensitive Design are: consideration of both direct and indirect stakeholders (that is, the users of technology and those affected by the technology even though they do not use it); a tripartite methodology, consisting of conceptual, empirical, and technical investigations, iteratively and integratively applied; and an interactional theory to the value implications of technology.

In other prior Value Sensitive Design work [3, 4], the researchers found it valuable to draw a distinction among stakeholder values, explicitly supported values, and designer val-

[5]http://seattlelighthouse.org/

ues — an important designer value for us is avoiding paternalism toward people with disabilities.

In the work reported here, we focus on one key set of direct stakeholders: the information contributors to the StopInfo application. Prior work has investigated values associated with other direct stakeholders of this application, notably blind and low vision users of StopInfo [5]. We also identified general users of StopInfo as direct stakeholders, and bus/train operators, orientation and mobility (O&M) instructors, KCM staff, and family and friends of blind and low vision users of StopInfo as key indirect stakeholders.

Value Scenarios. Other projects utilizing Value Sensitive Design have made use of *value scenarios*, a technique for envisioning the effects of technology designs while in the formative stages of design when value priorities are still unknown [23]. Value scenarios are brief fictional descriptions meant to evoke social and value implications associated with a hypothetical technology or feature design. For example, Czeskis et al. use value scenarios to explore the potential impact of a hypothetical mobile location monitoring application on parent/teen relationships [6].

Value Dams and Flows. Another methodology introduced in previous work [21] that we utilize here is value dams and flows. *Value dams* refer to the technical features or organizational policies that are strongly opposed, even by a small percentage of stakeholders. Once dams are removed from the design space, value flows are considered. *Value flows* are defined to be the technical features or organizational policies that a large percentage of stakeholders would like to see included as part of the overall system. Taken together, dams and flows can alleviate the concerns of minority groups and help support the desires of the majority.

RELATED WORK

As part of the conceptual investigation for uncovering motives and values surrounding information contributors' use of StopInfo, we overview related work regarding motivations for contributing to crowdsource efforts and conclude with prior work on gaming and reputation systems.

Motives for Contributing. Much work has been done on investigating motives for contributions to crowdsourcing technologies such as Wikipedia [25, 30], citizen science projects (e.g. Stardust@home, FoldIt, GalaxyZoo) [9, 24, 27, 29], question and answer forums (e.g. Yahoo! Answers [8], Math Overflow [31]), open source projects [25, 34], and other knowledge-sharing systems [21]. Additionally, Moore et al. investigated how type and purpose of a virtual community (e.g., wikis, blogs, or Internet forums) correlates with members' motives for participating [22]. While these works identify a range of potential motivations for contributing, in our work presented here, we also surface tensions that might arise from supporting certain motivations (such as competition) in the StopInfo system.

A system that provides detailed transit stop information can be viewed as a specialized geowiki. OpenStreetMap[6] is arguably the largest geowiki. Haklay [13] provides an assessment of the success of OpenStreetMap, both in terms of accuracy and coverage, in comparison with Ordnance Survey datasets in the United Kingdom. Another notable geowiki is Cyclopath for bicyclists [26, 28], which also includes route-finding capabilities. However, it is unclear whether motivations for contributing to wikis such as Wikipedia (which is perhaps the most well-studied) extend to geowikis. For example, Moore et al. 2007 identify the motives of *altruism*, *belonging*, *collaboration*, *egotism*, *knowledge*, *power*, *reciprocity*, *reputation*, and *self-esteem* as pertaining to wiki participation [22]. However, a system such as StopInfo or OpenStreetMap requires simple contextual knowledge (i.e., physical features that are present in a specific area) rather than expert knowledge; thus, it is unclear whether motives such as knowledge (in the sense of improving knowledge rather than sharing), reputation, or power might apply. The StopInfo system also differs in that it is tied more to a physical community (in this case, the Seattle area), rather than a virtual community.

To the best of our knowledge, contribution behavior and motivations surrounding crowdsourced transit information systems such as Waze or MiFlight are not currently well-studied. Work by Lathia et al. in 2014 regarding transit riders' experiences with a crowdsourced transit information system for the London Underground called TubeStar mentions studying contributors' motives as future work [18]; however, we have been unable to find much other discussion of this specific topic.

Reputation and Badge Systems. Prior literature has shown that certain game elements, such as earning points and unlocking achievements (i.e., badges), has led to increased participation and sustained contributions [1, 7, 20]. Based on this literature, badges can also serve as a representation of *community membership*, *authority*, *competence*, *experience*, *identity*, and *reputation* [14].

FORMATIVE WORK

Initial work on the StopInfo system focused on the values of blind and low vision transit riders, the primary group for which it was designed [5]. However, the system would not be useful to this stakeholder group (or StopInfo users in general) if the information provided is not reliable, meaning that it must be both *accurate* and *complete*, as previously discussed in the StopInfo section.

To bolster the completeness and accuracy of StopInfo information, we investigated the motivations and values associated with contributing to StopInfo with former and potential contributors, in hopes of being able to increase and sustain the level of contributions while promoting high-quality submissions.

Formative Study. During the summer of 2014 (five months after StopInfo deployment), we performed a formative study by surveying 15 StopInfo contributors and 31 non-contributors. The survey addressed the basic usability of our current StopInfo system and asked about potential motivations for contributing information about bus stops.

[6] http://openstreetmap.org

We also conducted follow-up semi-structured interviews with nine of the survey participants, which focused on what their main contributions are or would be for contributing to StopInfo, and their views about the system being run by a research group versus transit officials at KCM. One of the more interesting findings from these interviews was the emphasis on wanting to interact with and benefit the community — in subsequent interviews (discussed in the Results section), we sought to determine more precisely how the participants understood the term 'community'.

Low-Cost Conditions for Submitting. From these results, we also learned what might entail favorable (i.e., low cost) conditions for contributing information. That is, intrinsic motivating factors and incentives aside, StopInfo contributors and non-contributors alike reported that they would be most *easily able* to contribute to StopInfo if:

- It is easy enough to get to StopInfo within the OneBusAway application.
- They are aware of the presence of StopInfo while waiting at a bus stop.
- They have free time while waiting for their bus.
- The form is quick to fill out and the categories of information are unambiguous.

The above cases mostly center around system usability, opportunity to enter information, and salience. In terms of conditions that we can directly impact, we are continually working to improve the salience and ease of access of the StopInfo feature within OneBusAway, in addition to highlighting the option to edit stop information while the individual is viewing that stop's information page. Outside of the system itself, we are also participating in outreach (e.g., attending relevant events and sending out press releases). We would also like to put up physical notices (along with Braille translations) at bus stops around Seattle to draw attention to the StopInfo feature.

Incentivizing Higher Cost Submissions. Additionally, we learned that some contributors would be willing to submit information at a higher cost given enough incentive and/or intrinsic motivation. Cases in which the cost for submitting information would be higher for contributors include (but are not limited to):

- Going out of their way to visit a stop that is in need of information.
- Memorizing or taking pictures of stop features to reference when filling out an information form for that stop at a later time.
- Submitting information despite finding it boring.

To mitigate some of these costs, we can work to enhance ease of use within the system itself (for example, by letting users take pictures of the stop directly from the app, or highlighting which stops need information on the map), bolster the motivations of those who are willing to endure a higher cost (such as showing them the direct impact of their submission), or add further incentives (such as a badge that rewards breadth of contribution, monetary or physical rewards, or an optional scavenger-hunt-like game). This motivates the question of whether people would be responsive to these types of features, or whether they might actually *discourage* contributions. We investigate this question in a subsequent study, discussed shortly.

VALUE SCENARIOS FOR STOPINFO

Based on the conditions for submitting outlined above, we composed two value scenarios that highlight some of the values and potential uses (and misuses) of the system implicated by adding incentives, such as a game, to the system.

Value Scenario: Exploring the City with StopInfo. Growing up, Lisa has always enjoyed solving puzzles and going on scavenger hunts. Over the past year since she's moved to Seattle, she has gotten really into the geocaching[7] phenomenon with her friends. She's found hidden geocaching tags while on hikes, exploring landmarks downtown, and dining at some of the city's local restaurants. Lisa regularly takes the bus to explore these new destinations, and when she learns that the StopInfo system now has a geocaching-like game for some of the bus stops in the Seattle area, she is excited to participate, since now her explorations will also benefit others in the Seattle community. She begins to routinely visit new stops in order to try and find 'tagged' stops by entering information in StopInfo for those stops. She becomes a top scorer in the system, and she and her friend Andrew routinely battle for a higher ranking.

A few months later, Lisa twists her ankle while playing soccer and is forced to use crutches for a few weeks. Now, exploring stops that are out of her way is much more of a hassle, especially in some of Seattle's famously hilly neighborhoods. Andrew zooms past her in the rankings, sending a few gloating messages her way. The competitive side of Lisa is fired up, and she decides to resort to other methods to 'explore' new stops. She first uses Google Street View to look at pictures of stops she cannot reach by foot and enters information in StopInfo. She uncovers hidden tags in no time, regaining her footing over Andrew, and wonders why she didn't think of doing this in the first place.

Andrew becomes suspicious of all of Lisa's activity given her injury and visits one of the stops she has recently entered information for. He notices the information she entered is mostly accurate, but that she had entered information for the wrong type of sign. When he accuses Lisa of cheating, she confesses that she used Google Street View to fill in the information. He sighs and tells her those photos are at least a year old, and the sign must have since been replaced for that stop. This kills the honest fun of the game between the two, and they begin to trust the information that other contributors have entered much less.

Discussion. This scenario highlights the motivating power that games such as geocaching hold in addition to some of the potential pitfalls. In the scenario, Lisa and Andrew both start playing the game to have fun, explore new areas, and benefit others who are using the system. However, as they

[7] https://geocaching.com/

become more competitive, Lisa resorts to gaming the system in what she perceives as a harmless manner. She focuses more on the competitive element of the system rather than its goal, and ends up contributing less accurate information as a result. This ultimately undermines the purpose of StopInfo for them, as well as the end users who encounter and may even trust the inaccurate information, and perhaps also other StopInfo contributors who detect the gaming of the system.

Without ample accurate information as a baseline, it would be difficult to monitor all submissions of information from people playing the game. In this scenario, we can see that competition can sometimes lead to inaccurate submissions, whether the intent is malicious or not. Designing a game like the one described above would have to be done with great caution to make sure that the quality of submissions does not suffer as a result. Furthermore, merely the inclusion of a game in general can potentially undermine submissions from those who are not interested in competition and/or incentives and want to submit information for altruistic reasons.

Value Scenario: Community. We also wrote a second value scenario to highlight the value of community and its role in encouraging participation. For brevity we do not include it in detail here. In summary, it involves a group of volunteers who organize "stop-a-thons," in which the group periodically fans out in a particular neighborhood and enters information for all the stops in the area. In the process, in addition to getting data entered comprehensively for a particular neighborhood, the group engages with passersby and residents about the transit system, its role in the neighborhood, and how the system could be improved.

HARMS AND BENEFITS ANALYSIS

For the next phase of our conceptual analysis, we utilized another method associated with Value Sensitive Design: the identification of harms and benefits associated with the StopInfo system for StopInfo contributors [21]. To conduct the analysis, we utilized the findings from our literature review on other contribution-based systems similar to StopInfo, the results from our formative empirical study, the value scenario about gamification of the system, and the informal feedback we have received from the community through outreach events and e-mail. We hoped to systematically consider different potential designs of the StopInfo system to evaluate harms and benefits associated with the inclusion or omission of particular features, such as the top contributor list, a required sign-in, or a request system. The designs we evaluated are presented in Table 1.

After listing the potential benefits and harms associated with each system for StopInfo contributors, we mapped them to underlying values. For example, some of the values associated with the addition of the reputation system included recognition, both by us (the system administrators) and by other StopInfo users, reputation (in the Seattle community or within the system itself), self-esteem, and privacy. Other potential values implicated by StopInfo include self-efficacy (the feeling that one's contributions are useful), safety (in this case, physical well-being), entertainment, and community, which we further break down into *belonging to community* (feeling that one is a part of a group or collective identity), and *concern for community* (or altruism).

Thus, this phase helped us produce a list of values mapped to designs of particular features that we could evaluate empirically in order to determine contributor's value priorities, perspectives on some of these potential harms and benefits, and the impact of including or excluding certain features in StopInfo.

EMPIRICAL ANALYSIS OF CONTRIBUTOR VALUES

After completing our conceptual analysis for StopInfo contributors, we conducted an empirical investigation to explore how important these values are to the different stakeholders, and to highlight potential value tensions that might arise among StopInfo contributors or with other stakeholders, such as blind and low vision users of the system.

METHODS

Online Survey. To begin the empirical investigation, we created an online survey for both StopInfo contributors and non-contributors (primarily those who are frequent public transit riders and OneBusAway users). We distinguished between two types of non-contributors: willing non-contributors, who said they had not previously contributed to StopInfo but were willing to in the future, and unwilling non-contributors, or those who said they had not contributed before and probably never would.

The survey included structured questions based on some of the values identified in the harms and benefits analysis, as well as open-ended questions that allow for unstructured feedback. The survey was structured as follows, with each item corresponding to a different page of the survey:

1. A consent page that informed them of the purpose of our study.
2. Questions about public transit and OneBusAway usage.
3. An overview of the StopInfo system including screenshots and a link to the live user interface, what information we collect from contributors, and the goal of the project.
4. A question asking whether they have previously contributed to StopInfo.
5. Open-ended questions about motivations for contributing and concerns with the current system.
6. Structured questions (answered on a 5-point Likert scale) about why they may or may not contribute.
7. Both structured and open-ended questions about potential new features and designs of the StopInfo system (including what information they would feel comfortable or uncomfortable with being collected or displayed as part of contributing).

In our structured questions in Part 6, we sought to distinguish who was meant by 'community' by distinguishing among three different groups: other transit riders in the Seattle area,

Design	Features
Original StopInfo design	* Sign in optional, only a display name and e-mail address collected when signed in * No identification of stops that need information * No badges, points, or top contributor list
+ reputation system	* Addition of top contributor list and points earned for certain behaviors * Can submit information anonymously, but required to sign in with Facebook or Google account to participate
+ badges	* Badges earned for certain behaviors and are associated with the device ID used to submit information * Do not need to sign in to earn badges
+ anonymous requests	* Identification of specific requests from StopInfo users * Requestor and responder both anonymous
+ blind/low vision requests	* Identification of specific requests from StopInfo users * Requestor can optionally self-identify as blind or low vision
+ personalized requests	* Identification of specific requests from StopInfo users * Requestor and responder must sign in and both can view display name and/or pictures
+ optional game	* Support for a geocache-like game that incentivizes traveling to particular stops to search for clues

Table 1. Alternate system designs that we used for harms and benefits analysis. Each row specifies different designs of the system based on the addition of that feature.

the transit agencies in the Seattle area that maintain the stops, and the community of blind and low vision people. We also sought to distinguish the differences between peoples' comfort with providing certain types of information (such as their names, e-mail addresses, GPS locations, and the stops they have contributed to) by having them consider two types of systems: an *opt-out* system, where this information is automatically collected unless they explicitly change a setting to keep us from collecting it, and an *opt-in* system, where this information is *not* collected unless they explicitly change a setting that would allow us to collect it.

We recruited for the survey by sending it to a few local e-mail lists, posting it on a popular transit-oriented blog in Seattle, and creating an alert with a link to the survey within the OneBusAway iOS application, which is used by about 100,000 users in Puget Sound per week. We additionally placed an accessible banner within StopInfo itself that linked to the survey and posted a message asking contributors to take the survey after they submitted information for a stop. To incentivize participation, we offered the chance to win a $50 gift card by allowing participants to enter their e-mail address at the end of the survey.

We gathered 793 responses to our survey (51.6% male, 47.6% female, ages 18 to 85, $\mu = 37.1$ yrs) from 135 contributors (or 'C') (58.9% male, 41.1% female, ages 18 to 67, $\mu = 37.2$ yrs), 502 willing non-contributors ('NC-W') participants (52.9% male, 45.9% female, ages 18 to 71, $\mu = 36.9$ yrs), 140 unwilling non-contributors ('NC-U') participants (39.6% male, 59.7% female, ages 18 to 85, $\mu = 37.6$ yrs).

Followup Semi-structured Interviews. At the end of the online survey, we asked participants if they would be willing to participate in a follow-up phone interview with a member of our research team. The interviews were semi-structured [17] and designed to last approximately 20 minutes in length. Interview questions addressed the main reason or reasons the participant has for contributing (or potentially contributing), any concerns they might have about the current system, who they wish to help impact with their submissions, thoughts on potential designs of the request system, and their feelings about gamification of the system (i.e., a reputation system, badge system, and inclusion of an optional game). The order questions were asked and the wording of them were fixed. Some questions asked in the preliminary survey were repeated in some form to clarify any ambiguity that was present in the study.

The interviews were conducted during a two week period following the online survey. Altogether, 23 participants were interviewed (62.5% male, 37.5% female, ages 25 to 64, $\mu = 41.8$ yrs). Ten participants identified as C (80% male, 20% female, ages 25 to 64, $\mu = 43.2$ yrs), 12 NC-W participants (58.3% male, 41.7% female, ages 25 to 62, $\mu = 41.4$ yrs), and 1 NC-U participant (age: 33 yrs).

RESULTS

We discuss the results from second round empirical investigation by *themes* centered around a group of questions that we defined ourselves, or that arose from participant responses. We show results for our structured survey questions for all contributor groups (C, NC-W, and NC-U) in Tables 2 and 3. However, we put more emphasis on results from only C and NC-W participants, since they will be the primary users of the StopInfo system.

Community. Consistent with our formative investigation, the reason most participants gave for contributing or potentially contributing information was to benefit the community. For all participant groups, the most positive response was toward helping other transit riders, in both our Likert questions in Table 2 and open-ended questions about their main reason for contributing. There was also strong support for helping transit agencies, who would in turn help them and other riders by providing better service. Some people also mentioned that they were "giving back" to the community, as well as the maintainers of OneBusAway, since they appreciate the public

Table 2. These tables include some of the structured questions in Part 6 of the survey. Percentages reflect the number of participants who responded 'Agree' or 'Strongly agree' (for benefits questions) or 'Strongly agree' (for harms questions) out of the total responses to the question, not including blank responses. An * indicates harms $\geq$ 10% value dam threshold, and a † indicates benefits $\geq$ 50% value flow threshold.

Associated Value(s)	Benefits-related Questions (Flows)	Percent Agree or Strongly Agree		
		C ($N = 135$)	**NC-W** ($N = 502$)	**NC-U** ($N = 140$)
	I would enter information (or would enter information) because it...			
Community	...is helpful to other transit riders.	82%†	87%†	65%†
	...is helpful to people with visual impairments.	62†	78†	58†
	...is helpful for transit agencies in improving their service.	73†	79†	55†
Reciprocity	...is a way of "giving back."	64†	65†	41
Recognition	...is nice to be recognized for something useful.	29	29	13
Entertainment	...is fun to compete with other StopInfo contributors.	21	16	7
	...is fun to work with other transit riders to improve the data.	57†	50†	19
	...is something to do while waiting.	61†	59†	32
Reputation	...can benefit my reputation in the Seattle community or among peers.	19	12	8
Reliability	...is frustrating to see a lack of information for a particular bus stop.	60†	57†	41
	...is frustrating to see inaccurate information for a particular bus stop.	69†	72†	53†

Associated Value(s)	Harms-related Questions (Dams)	Percent Strongly Agree		
		C ($N = 135$)	**NC-W** ($N = 502$)	**NC-U** ($N = 140$)
	I would probably NOT contribute any information if...			
Reciprocity	...I didn't find the information provided by the system personally useful.	13%*	10%*	24%*
Entertainment	...I found it tedious.	21*	30*	38*
	...I earned all the badges.	6	4	6
Competition	...the system became competitive.	18*	11*	17*
Self-efficacy	...I couldn't tell if the information I contributed was being used by anyone.	14*	8	15*
	...other people overrode some of the information I entered.	12*	5	9
Privacy, anonymity	...I had to sign in in order to contribute.	25*	17*	26*

transit system and the tools that support it. As one survey respondent stated, "*...it's a way of giving back and it will help both transit riders and the transit agencies. I rely on public transit as my primary mode of transportation, so I want to help give back as a gesture of appreciation.*"

While many people agreed with the statement that they would contribute to help people with visual impairments, the response was not as strong as for the general community of transit riders. This may be due partly to the fact that it was not immediately apparent that the goal of the project was to collect this information to benefit visually impaired riders within the StopInfo or OneBusAway interface. After the goal was explained, one interviewee stated, "*I know [the visually impaired] have a hard enough time navigating around... so I figure I could help make things easier for them as it is rewarding.*" Some contributors did tell us that their main reason for becoming aware of and/or contributing to StopInfo was that they or someone they knew had a visual impairment, and had heard news of our project through channels in the blind community. However, generally contributors and willing non-contributors alike said that they wanted to help the general community of transit riders, including people with visual impairments or other disabilities. This altruistic value was a common theme throughout the interviews. One interview participant said, "*...if there is an area [that] isn't as high trafficked and someone would like information on it, then I would be glad to take the time to give them it, especially if they were visually impaired.*"

Data Accuracy. A value that arose from our survey and interview results that we did not specifically ask about was the desire to help build and maintain a collection of accurate data, regardless of what it was being used for. In the open-ended question about what was a person's most *important* motivation for contributing, 11% of contributor responses and 20% of NC-W responses were coded as 'helping build an accurate data collection'.

One reason participants sought to increase accuracy in bus stop data was rooted in a frustration with seeing inaccurate or incomplete data, as all participant groups had strong agreement rates (over 50%) with our statements about frustration

Associated Value(s)	Potential mechanisms	Percent 'Important' or 'Very Important'		
		C ($N = 135$)	NC-W ($N = 502$)	NC-U ($N = 140$)
	I would like to know...			
Self-efficacy	...how frequently the information I entered was being accessed or used.	44%	38%	33%
Visibility, saliency	...what stops need more information around a particular location.	74†	73†	56†
Community	...if there are specific requests for information from anyone in the community.	68†	74†	54†
	...if there are specific requests for information from blind or low vision transit riders.	69†	77†	63†
	...if other people are entering information about stops in my area.	39	39	29

Table 3. This table includes some of the structured questions about potential features that participants would "like to see" as part of the StopInfo system and how important they are to them. Percentages reflect the number of participants who responded 'Important' or 'Very important' (for benefits questions), not including blank responses.

with the data (Table 2. Furthermore, 21% of contributors and 18% of NC-W survey participants saying it their primary reason for contributing or potentially contributing information to StopInfo was due to frustration with data quality. As one NC-W participant wrote, "*More information is better... it is frustrating if a stop is closed and I don't know about it until I get there.*"

Salience and Visibility. Although we did not address these values directly in our survey or interview questions, a common theme that arose from our investigations was around the salience and visibility of the goals and usage for StopInfo contributions (such as who it is meant to benefit and how often it is being used). There are two aspects of this. The first involves prominence of StopInfo and the contribution within the OneBusAway app, so that there would be a subtle reminder for entering stop information while riders are waiting at the stop. This point was mostly brought up by our NC-W participants, who by and large said they hadn't contributed before because they were unaware StopInfo existed, even though they are frequent users of the OneBusAway app. However, contributors also brought up that they would be more likely to contribute if they had a subtle reminder while they were waiting at the stop, such as a non-intrusive prompt on the stop's arrival times page which asks if they would be willing to contribute information for that stop.

Secondly, contributors and non-contributors alike valued visibility regarding why we are asking riders to contribute and whether the information that is contributed is used. Roughly 40% of C and W-NC participants said they would like to see "how frequently the information I entered was used or accessed" (Table 3), and in the open-ended question to contributors that asked what was likely to make them contribute more often, some suggested that knowing the information was being used either by other transit riders or transit agencies would make them more likely to contribute over time. It was also clear from survey responses that many people thought the transit agencies were the ones requesting and using the information that they contributed, which is inaccurate, and suggests that we could do a better job of making the project goals clearer in the design.

Gamification. Participant's perspectives on gamification were some of the most polarized results of our study. However, some forms of gamification were better received than others. We discuss each in turn.

Reputation System

As mentioned previously, the reputation system gamifies StopInfo by awarding points to information submissions, and highlights the system's top ten contributors (ranked by points). In our survey, we asked if participants thought it was useful to have a reputation system in StopInfo. After coding the free-text responses, there was nearly an even split between 'Yes' and 'No' for both C and NC-W groups. Many participants highlighted the pros and cons of a top contributors list in their responses, including an appreciation for recognition for their efforts, but also possible abuses of the system in order to gain points. For example, one NC-W participant who was for the reputation system wrote, "*For certain applications I follow certain contributors because I trust their information more. For things which could really change my schedule, such as stop closures, reroutes or some other radical problem it might be nice to see that the contributor is verified in some way.*" Another NC-W participant against the reputation system said, "*No. I think that will lead to an exclusive community of people who contribute, and make people who don't have time to rack up points be reluctant to contribute. A reminder that contributions are possible and helpful might work better.*"

Some previous contributors said they were more likely to sustain their contributions if there were ways to redeem their points for rewards, such as $5 Starbucks gift cards or bus fare added to their passes (rather than the one-time use paper tickets that we distributed before). However, others expressed concerns about this leading to false information, or undermining other motivations, such as contributing for more altruistic purposes.

Badges

Participants were mostly indifferent toward badges. Participants against including badges called them "childish" or

"silly," but others recognized their utility in incentivizing certain behaviors, such as seeking out new stops or responding to requests. The general sentiment is summed up well by one survey participant, who wrote, "*I myself do not put much emphasis on those types of badges, but I know plenty of people who do. It does not bother me to have that included either, unless the app pressures you to link to some social media to share your status (but an opt out link is just fine for me).*" Participants acknowledged that others may enjoy a badge system, thus stating satisfaction with its inclusion in the design, provided it be optional to sign in. However, most interviewees preferred to not be bothered by badges or other distractions and preferred to simply be able to go into StopInfo, enter information, and get out.

Geocaching-like game

Participants responded more positively about including an optional geocaching-like game as part of the system, with some who were even enthusiastic ("*Would be on it a lot more. Love the idea!*"), and many who were indifferent ("*I wouldn't participate in it, but maybe some people would like it*"). Those against the idea again mentioned that it seemed unnecessary, pointed out the possible dangers (such as those brought up in our value scenario), or that they wanted "*...this app to be as simple and clean and lightweight as possible. I do not feel any need to gamify my bus app.*"

Privacy. Other findings from our empirical investigation suggest a strong value dam (using the $\geq$ 10% threshold from [21]) around requiring a sign in. We also asked a series of questions around what information they would feel comfortable with us collecting and storing, in the format "Please indicate how comfortable you would feel if the system logged any personally-identifying information (display name or e-mail address) along with..." The pieces of information we asked about included how many times they contribute, what stops they contributed information to, and their GPS location when they contributed information. We also differentiated between opt-in and opt-out systems. They rated their comfort level on a 5-point Likert scale ranging from "Very uncomfortable" to "Very comfortable." Due to space considerations, we omit the response table to these questions for each contributor group; however, it is worth noting that each piece of information that we suggested collecting had over a 20% response rate of 'Very uncomfortable' (and for GPS locations, over 40%), regardless of whether the system was marked as opt-in or opt-out. This strongly suggests not only that we should keep the option for contributors to remain anonymous, but that we should make what we do and do *not* collect very clear.

DISCUSSION AND FUTURE WORK

Next Steps. As Value Sensitive Design encourages an iterative process that touches every phase of technology design, we will use the results of these second-round conceptual and empirical value investigations to evolve our design, as well as undertaking further conceptual, technical, and/or empirical investigations.

Limitations. Since our results are largely based on self-report, there is potential for inflated responses that indicate socially-desirable traits (such as altruism), and the reduction of those that indicate less desirable ones (such as recognition or self-gain). While we wish we could address the question of whether in fact contributors value reputation, recognition, or rewards more than they claim, there was not substantial enough data from our system log to determine the impact of our reputation system on contributions. We asked contributors in our survey if they had noticed the top contributors list, points, and/or badges before taking the survey, and only 13% (or 18 people) answered 'yes', suggesting a lack of discoverability of those features within the UI. Furthermore, only three participants claimed the bus tickets we offered as a promotion, and we cannot say whether it was due to a similar lack of visibility, low utility (many claimed they already had monthly passes, so one-time bus tickets wouldn't incentivize contribution), or if they just were uninterested in claiming the reward.

Secondly, there may have been a sample bias for our survey and interview participants. We incentivized the survey by offering a drawing for a $50 gift card of their choice, but interviewees participated solely on a volunteer basis. Thus our participants might have responded more strongly toward altruistic values. (However, if these are the people who will be potentially contributing information to our system, then isn't it their values we wish to support?)

Designing a Request System. The Value Dams and Flows method [21] seems particularly applicable to deciding on directions for future technical investigations. The results summarized in Table 2 indicate that there is a clear value flow especially around being helpful to other transit riders, as well as to people who are blind or low vision and to transit agencies. Thus, adding features supporting this value seem likely to improve and sustain participation. One such promising feature is a request system that would allow either the general transit riding population, or self-identified blind and low vision riders, to mark a transit stop as one for which they would appreciate information being added. Early contributor survey results indicated some desire to know if a request is coming from a person who is blind or low vision (33% of all respondents marked this as "Very important" to know, while 22% marked "Very important" for any transit rider). Preliminary interview results supported this finding, with some interviewees noting that they felt the information would be more useful for someone who is blind or low vision, thus making them more likely to respond to the request and provide more detailed information.

However, earlier work with blind and low vision people alert us to potential value dams with respect to such a feature. There is generally a strong desire to be treated like everyone else as much as possible, rather than being singled out as having a disability. In addition, blind and low vision people regularly experience unwanted offers of inappropriate help.

In response to this analysis, our current design is to *not* provide a mechanism for requestors to indicate the reason for their request. Instead, we would include a note (in a popup help bubble, for example) saying that the request is from a fellow rider — it might be from a blind or low vision rider, a

wheelchair user, an elderly person who uses a walker, someone from out of town planning a trip, someone wondering whether the stop is well-lit at night, or just someone who wants that particular stop to be well-described. This design choice and recommendation for similar systems is supported by our finding that the strongest reason for providing the information was to be helpful to other transit riders. Our interview results provide some support for this choice, for example: "*If somebody had a question and I hand [sic] an answer, it wouldn't matter if they were sighted or not,*" and also "*I feel people with visual impairments need more help but I would already be inclined if anyone asked for it.*" In future work, we plan to implement and then evaluate this design. Stepping back, note the interplay between the VSD analysis, in particular the consideration of the different stakeholders and of value dams and flows, and the design of the technical mechanism. Finally, although we did have some blind and low vision transit riders who contributed information to StopInfo, we did not consider them separately in this analysis. In future work, we want to consider blind and low vision riders specifically as contributors and potential contributors, and elicit feedback from multiple stakeholder groups in concert to learn how to optimize the system for the most users and contributors.

Competition and Games. Another issue concerns competition. There is a clear value dam around making the system competitive. Similar attitudes also surfaced in a majority of the semi-structured interviews. One participant claimed, "*I think the people that are motivated to help people that are low vision are not generally motivated by top contributors lists.*" This, along with the tension between competition and community, suggests that we *not* pursue designs that introduce such a competitive element, instead emphasizing community. If a game were to be introduced into StopInfo at some point in the future, we would take special care to make sure it is collaborative rather than competitive in nature. As one survey participant puts it, "*I'd gamify it, but I wouldn't include a competitive aspect. You're trying to instigate prosocial behavior... competition seems [antithetical] to your aims.*" Participants assumed a dissonance between competition and collaboration. Future work could consider how to gamify systems to support both the quantity and quality of contributions, and to consider how StopInfo can positively portray disability, particularly by designing to connect those with disabilities with those who enjoy gaming and competition.

Additional Empirical Investigations. In addition to this work on designing and deploying additional technical features, we want to conduct further empirical investigations with StopInfo users (building on the prior work reported in [5]), to complement the work reported here, which concentrates on StopInfo contributors.

For this work, our motivation for focusing on previous and potential contributor values was to incentivize increased and sustainable participation, while maintaining quality submissions. We also wish to do another iteration of investigations on those utilizing information about bus stops, and determine how the design of our request systems or other mechanisms might support or detract from their values. We hope that these results will be both an artifact — a system that is useful, effective, and supportive of the value of community — as well as contribute to our broader understanding of how to deploy and sustain such community-oriented, geographically-situated information systems.

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