Mobile Transit Rider Information Via Universal Design and Crowdsourcing

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ABSTRACT

Extensive interviews with riders of the Pittsburgh bus system revealed that, as the top priority, riders want to know the current location of buses. Using a universal design methodology, we designed a system, named Tiramisu, to foster a greater sense of community between riders and transit bus service providers. Our design focuses on crowd-sourcing acquisition of information about bus location and fullness, predicting the arrival time of buses, and providing a convenient platform for reporting problems and positive experiences within the transit system. This will create a user community of riders that are participating in the delivery of service. Tiramisu also supports specific information and reporting needs for riders with disabilities, thereby providing greater independent mobility around the community. Early field testing of Tiramisu suggests our approach is both feasible and potentially viable. In summary, Tiramisu is valuable enough for riders to commit time and effort to its use to produce a sustained user community.

INTRODUCTION

Information and Accessibility

The emergence and ever increasing adoption of both web 2.0 communication technology and smart phones has begun to change the service delivery landscape for transit. This new technology and infrastructure allows for ongoing, real-time information exchange between riders and service providers. Riders can literally function as sensors within system, feeding in a range of information. Transit services can leverage the devices riders carry to push out dynamic information, such as alerts about construction, traffic accidents, and water main breaks. This dialog between service providers and their customers can produce a much more dynamic service system than could ever be imagined in an era of printed, paper schedules. This more reactive system will significantly improve the quality of the service, especially for communities like people with disabilities, who have a significantly higher rate of dependency on these services and their support infrastructures.

To demonstrate this opportunity, we are developing and deploying Tiramisu[1], a mobile web 2.0 system intended to connect riders and a transit service. The Tiramisu system allows riders to generate and share GPS traces and fullness ratings via their mobile phones. This data is then aggregated in order to provide real-time arrival and fullness information. The riders collectively generate the information they desire, circumnavigating the need to install expensive commercial systems. In addition, Tiramisu allows riders to report problems with the service and allows the transit service to push out dynamic information about temporary states of the current service that are filtered and displays to the specific riders who are affected by these changes.

Our approach comes from "citizen science" – a concept where citizens individually collect small pieces of information and aggregate them together in order to gain more insight and control over their world (Paulos, 2008). The primary mission for the Tiramisu system is to increase information exchange in a universal design manner in order to support higher quality transit experiences and greater independent mobility around the community. In addition, we hope to create a sense of ownership of the public service by the citizens that use it by having them co-construct part of the service they use. We seek to do this through a sustainable community of practice model that involves transit consumers and service providers in a collaborative dialog. This type of data collection and sharing by riders surfaces currently unknown information to the transit service providers, thereby enhancing their ability to plan schedules, adapt to dynamic conditions, and prioritize accessibility improvements in areas where riders are actually experiencing problems. Utilization of this new source of data will enable service providers to implement total quality and continuous improvement practices more effectively.

Status Quo and Related Work

The general problem all riders face, especially people with disabilities, is uncertainty and anxiety around transit service delivery. For example, when riders arrive at a stop near a scheduled time, they have no way of knowing if they have just missed their desired vehicle, if the vehicle is seriously delayed, or if some unexpected event has temporary cancelled the service at this location. Riders feel "out of control."

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[1] Tiramisu means "pick me up" in Italian.

Under the status quo, drivers are the most natural point of communication for riders; however, drivers have many other concerns they might deem more critical to their job, such as safety and their own on-time performance. They do not possess real-time information about the location of other vehicles beyond their historic knowledge and they have little time to provide high quality information about routes, destinations, and schedules. When riders ask questions such as, "Does this bus go to the hospital?" a typical response might be, "No, you want the 61C. It will be here in about 5 minutes." when in fact, it might be completely full and unable to take additional passengers, extremely delayed, the wheelchair lift may be broken, or another bus going to this location might arrive sooner. By leveraging the communication network that already exists in the mobile phones riders carry to exchange information, drivers can be freed of this responsibility, and riders can have a more satisfying transit experience.

There are efforts to provide information to riders using mobile devices, some of which are designed specifically for people with disabilities. For example, the Travel Assistance Device (TAD) tested in Tampa, Florida directly supports riders with cognitive disabilities (Barbeau et al., 2010; Winters et al., 2010). In addition to TAD, a number of groups have explored delivery of transit information via mobile devices (e.g., Biagioni et al., 2009; Li & Willis, 2006; Masood & Nicholas, 2003) and other approaches have been used to support overall system navigation for riders with cognitive disabilities (Repenning & Ioannidou, 2006). There has also been concerted effort to support the general wayfinding needs of people who are blind or low vision using GPS (e.g., Humanware; Nuance) and directional LED beacons (Crandall et al., 2001).

There are also commercial systems on the market designed to support transit information delivery via mobile phones. A good example is RouteShout, which supports interaction through SMS and through applications designed to run on Android based phones and Apple's iPhones. Google has also recently deployed Google Transit into their Android map application. These systems are heavily focused on providing schedule and routing information and have limited, if any, methods for dialog between riders and transit service providers.

At the service level, there has been very little work on enhancing the information exchange between transit agencies and their riders. This state of affairs is unfortunate since better methods for acquiring input from people with disabilities have been highlighted as pressing need (Transportation Research Board, 2001). Therefore, the team has included service modeling in the research plan and used these findings to help guide our process (Yoo et al., 2010).

Reporting – Single Event Scenarios

Large, complex service organizations regularly have difficulty in knowing where there are barriers to services and where services are being effectively delivered. In the context of accessible public transit, this difficulty manifests itself as inaccurate information about accessibility barriers and cases where riders feel their agency is doing well. Most transit agencies do not have the resources to initiate systematic accessibility reviews of their entire system using conventional approaches such as longitudinal field studies, focus groups, and targeted surveys. These expensive and time consuming methods often fail to address both the immediate and long-term needs of riders and agency staff due to challenges in prioritization and tracking over time.

Traditional methods for documenting accessibility barriers include telephone customer service centers, voicemail, letters, emails, and community discussions. These "hard to track, archive, and share" methods lack good tools for revisions, grouping of cases, and tracking cases. Furthermore, service providers may not be able to monitor them for insight on how to improve their service offerings. New approaches are needed to promote adoption of best practices (National Council on Disability, 2005).

Passengers often encounter problems but then lack immediate information on how and where to report the problem. In addition, many traditional reporting systems, such as calling a customer service representative, do not allow for feedback on the state on the problem and confirmation that it has been recognized, assigned, and addressed. Without adequate feedback, riders making the effort to report problems can feel their efforts are falling into a “black hole.” In recasting riders as the owners of their transit service and not simply consumers of the service, web 2.0 technology can help riders to share their concerns with others, identify persistent and high priority problems, convey tips and hints on how to use a system most effectively, and consider the financial and social impacts of the service changes they request. People with disabilities obtain more benefits from system state information than other riders since surprises can lead to significant delays and detours (e.g., broken elevators). Similarly, travel trainers accumulate information on how their clients can best use a system.

Therefore, we propose that citizen science reporting approach is especially effective since information can be aggregated, analyzed and shared in a cost effective manner. In addition, data collection via mobile devices can streamline reporting processes by automatic capture key details (e.g., location, time of day, traceability to rider for follow-up questions and feedback, etc).

Reporting – Continuous

If mobile methods of data collection are used, it is also possible to incorporate continuous rider reporting. In the case of Tiramisu, we are targeting collection of real-time bus location and fullness estimates from riders. This information is then used to predict real-time bus arrival and fullness estimates into the future.

Providing real-time arrival information alone can increase ridership as much as 40% (Casey, 2003). This data is particularly important to people with disabilities. For example, they may be more vulnerable to exposure in severe climates or have medical needs that require attention on a timely basis. People with disabilities have also expressed concern about risk of theft and other crimes while waiting at bus stops. This aligns with findings for riders without disabilities reported that real-time arrival information system led to higher perceptions of safety (Ferris et al., 2010b). Results from this prior work included free form comments specifically regarding fear of waiting at night and at unsavory stops.

Unfortunately, real-time arrival data is expensive to implement and typically does not include information such as fullness. Engineering solutions for obtaining fullness are possible, but incur even higher costs. The high capital and operating expenses associated with proprietary real-time arrival data systems is the primary reason cited by agencies interviewed by the team for lack of adoption. The issue of fullness has been cited during our interviews with riders who use wheeled mobility devices. Without this information, they do not know if they will be able to get on the bus they are waiting for. As with single event reporting, these issues can be resolved through citizen science approaches.

SYSTEM DESIGN FACTORS

Early in the development of Tiramisu, the team identified four general factors that directly affected the design of the service and the implementation requirements. Universal design was founding principle of the design process and rich media event reporting was identified as a valuable approach early in the project. The remaining factors (crowd-sourcing and dynamic information push) surfaced during interactions with stakeholders.

Universal Design

Transit and public services have a mandate to support people with disabilities and other disadvantaged populations. In general, public services are designed to benefit everyone, but also to create a sense of fairness through their focus on services more specifically for disadvantaged communities. In our project, we seek to find harmony between in the needs of all riders by adopting universal design principles. The basic premise of this design philosophy is that designers should focus on services and systems that work for everyone within a single design. In taking this approach, designers consider the needs of all users from the start, instead of adding tacked on modifications designed to support the letter, but not the spirit of the ADA and similar laws.

Today, unfortunately, many transit information services are less than fully accessible. For example, static information such as signs indicating bus stops work well for most riders, but they fail blind and low-vision riders. Providing fully accessible systems at each stop (e.g. text and audible schedule information) is costly and is usually reserved for major transit terminals.

Our focus on universal design influenced several areas of Tiramisu. The preliminary fieldwork that investigated the information needs of riders and of transit service providers (Yoo et al., 2010) included interviews with a range of disabled as well as non-disabled riders. The interface and interaction design for the system were tested with disabled users. This testing resulted in additional functionality.

Multimedia Single Event Reporting

Earlier work by the team on how riders want to report problems examined rider preference, ease of use, usefulness, and social comfort when reporting accessibility barriers (Steinfeld et al., 2010a). Our investigation examined factors for modalities of the Notes (text, audio) and Media (none, photo, video) for both riders without disabilities and wheeled mobility device users. Participants documented representative problems in a simulated bus shelter using all six combinations (e.g., reporting a water damaged schedule sign using audio and photo). The results suggest that text with photos should be supported, and that riders do not perceive the use of video as adding additional value in terms of communicating the problem they wish to document. Both groups had a strong preference for the use of photos with text notes. This work evaluated rider preferences for communication but did not measure the effectiveness of the communication for the service provider.

To confirm that the use of photos and texts could form effective communication, the team convened a two-person panel that independently rated each participant's generated problem report collected from the previous study. Each report was rated on 7-point scales in terms of Detail, Context, and Clarity. The definitions provided to the panelists were:

- *Detail*: Problem understandability. Is there enough to understand out what the problem is… whether the step is 1" or 3", is it clear there is a maintenance problem, etc.
- *Context:* Scenario understandability. Can you tell what the item is and what the influences are… a step into a door vs. a step on a sidewalk, etc
- *Clarity:* Are there issues with the media that are masking the information… focus, grammar, background noise, tremor, etc

Statistical analysis showed no functional differences between text and audio notes. As with the preference and social comfort ratings seen in the prior study (Steinfeld et al., 2010a), Photo scored consistently well for all three measures (Figure 1). Tukey HSD post hoc analysis of

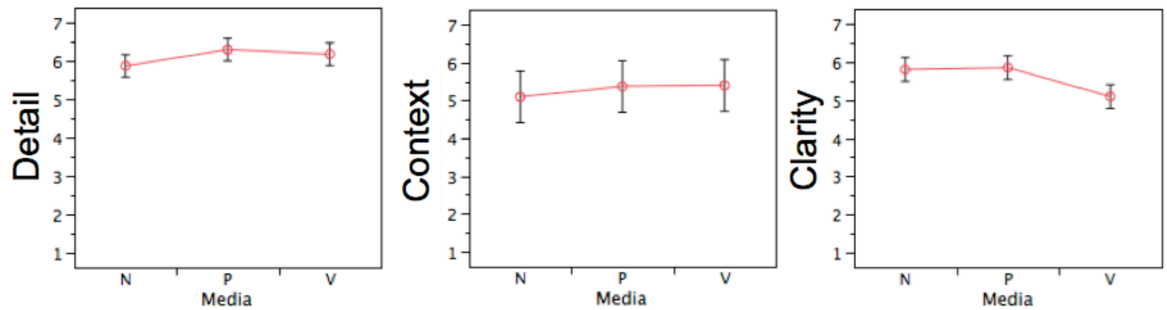

Figure 1. Panel ratings for report quality on Detail, Context, and Clarity for the Media conditions of None, Photo, and Video (1-7, higher is better)

an ANOVA showed that no media (None) was significantly worse than the Photo or Video for the detail (F=19.3, $p<0.0001$) and context (F=8.6, $p<0.001$) present in the report. Video was significantly worse for clarity (F=54.6, $p<0.0001$), most likely due to unwanted motion in the video and unnecessary footage at the start and end of the clips. While in-vehicle video has proven to be a valuable tool for capturing adverse events in transit systems, it does not seem to add much value to the information riders could collect and deliver to the transit service.

For this reporting, speed and ease of use is critical. Interviews and interaction concept testing by the team (Yoo et al., 2010) revealed that riders rarely encounter infrastructure problems that meet the perceived cost-benefit threshold for reporting. The benefit side of the equation is the perceived likelihood that a report will actually be seen and acted on. Analysis of survey questions about experiences with reporting problems to the local transit agency showed low rates of feedback and perceived timely resolution of the problem (Steinfeld et al., 2010b). This finding was not surprising given parallel reports from the transit agency that the customer service representatives rarely have time to return calls for issues other than lost and found (Yoo et al., 2010).

Using a single application for transit information sharing streamlines the experience and supports pre-loading of important real-time details (e.g., current location, route, etc), thereby lowering the perceived cost of submitting a report.

On the benefit front, we feel that providing methods for service providers to quickly and asynchronously provide feedback on reports is an important feature of the system. This feature has been shown to work well for groups like ParkScan.org (Neighborhood Parks Council, 2007) and our research plan includes field tests of these methods.

Crowdsourcing Continuous Data Collection

We are pursuing a crowd-source model for generating and disseminating real-time vehicle estimates rather than integrating a commercial system. A crowd-sourcing approach, assuming you can get a critical mass of participants, provides several advantages. First, it is significantly cheaper for the transit service than commercial systems due to the fact that it leverages a technical infrastructure that is already in place. Second, it allows for collection of many different kinds of dynamic information such as fullness of vehicle, available space for bikes, space for wheelchairs, etc. Third, the constant use of this service by many riders provides a platform for ongoing dialog between the transit service and riders.

Crowd-sourced systems and other online communities must deal with the issue of motivating participation. While many crowd-source models benefit from altruistic participants and a sense of ownership (e.g., ParkScan.org), our evidence suggests that this behavior is not prevalent in transit riders (Yoo et al., 2010). We suspect this difference is based on two factors. First, riders view transit as a "means" rather than the "ends." In a sense, riders engage with transit service not for the specific experience of the ride, but in order to efficiently achieve a different goal that requires them to move within a city. Second, riders of public transit services interact with the service much more like a consumer than other public services (e.g. visitors to public parks). Riders pay a small amount for each journey or they repeatedly purchase passes. This constant financial transaction may frame riders thinking of the service as a consumable service as opposed to a public good enabled by taxpaying citizens.

Work in the field of online communities has shown that there are key influencing factors for motivating participation (e.g., Ren et al., 2007) and that establishing successful online communities requires careful design. Factors like community identity and bond can be designed into the user interaction with the system to foster motivation. For this application, motivating users to sustain their relationship with the community is critically important. We recognize this as a challenge in the design of our system, and we are currently experimenting with several motivational models.

Dynamic Information Push

Our research with transit agency representatives showed a strong positive reaction to having the ability to push out dynamic schedule changes with short notice (Yoo et al., 2010). Agency representatives told a story about a parade triggered by the success of a sporting championship. This parade, with only two days notice, forced them to make a large number of routing changes. In order to prevent riders from waiting at stops that buses would never visit, they literally sent their employees out on the street to find stranded riders and send them towards the closest, temporary stops.

Some agencies have elected to use Twitter as a method for pushing real-time information out to transit users. One important feature of Twitter is that users can set up automatic mobile phone text messages. Twitter has also been suggested as a source for gathering real-time data from populations during evacuations and public planning (e.g., Brabham et al., 2010; Turner et al., 2010).

Some agencies use Twitter heavily and amass a large number of subscribers ("Followers"). In order to understand the effect of Twitter, we analyzed Port Authority of Allegheny County (PAAC) transit agency as a case study. PAAC is an interesting example because there were two large-scale disruptive events in Pittsburgh in one year – the 2009 G20 meeting and a week of major snowstorms in February 2010. Based on an analysis of PAAC's Twitter account looking at 222 days outside the two crisis regions, the account normally has an average of 2.1 new followers per day. The G20 occurred early in PAAC's use of Twitter and their account had 777 followers when the event started. The account gained 50 followers over the next two days. The snowstorms occurred about four months later. Two storms over five days left the region largely immobilized with many roads unplowed and major arteries severely constricted for over a week. PAAC used Twitter heavily during this crisis, often copying and pasting internal messages straight into the account (Schwartzel, 2010). Word of mouth about these updates led to giant increases in followers. For example, 151 followers joined on February 9th and were rewarded with 214 new messages the following day. No large drop in followers is present in the data after the snowstorms and the number of followers has steadily grown since the crisis. This phenomenon is not unique to bus transit services. Similar spikes in followers were seen for airlines during the Icelandic volcano ash cloud delays in the spring of 2010

(TwitterCounter, 2010). There seems to be a willingness within transit agencies to share dynamic information and a desire among riders to receive this information in a mobile, electronic form.

Our analysis of PAAC Twitter traffic revealed additional interesting behavior. Users posted questions and the agency posted replies to user questions on the PAAC Twitter feed. This two-way communication reinforced the value of this information resource and supported sustainability of this Twitter community.

Unfortunately, there are barriers to using Twitter for dynamic information. One speaker at a recent workshop remarked that an organization they worked with required multiple layers of approval for each Twitter posting (Zmud & Andrews, 2010). This approval process is obviously not suitable for the types of rapid updates required for real-time changes. Experts at the workshop recommend letting a designated employee post independently. Another barrier is that tweets are posted to all users, regardless of relevance. Syntax can vary and descriptions can be both narrow and broad (e.g., 61C vs. all routes in Oakland), thereby making it hard for a rider to rapidly extract relevant information. We are currently designing a system that captures Twitter traffic and routes the traffic directly to the relevant users.

SYSTEM DESIGN

User Interaction Design

This section details the rationale for specific design choices and the general interaction design. Specific features have been implemented and fielded (see Pilot Study, below) but others are still under development. The design of the mobile client app includes two main methods for contributing data. First, users can trace vehicle location and fullness and contribute Twitter-like messages. All of this data is linked to specific vehicles and stops. Second, riders can report single event observations with the option of including an accompanying photograph.

Tracing vehicle location and fullness is akin to a commercial automatic vehicle location (AVL) system combined with real-time fare counting. As mentioned earlier, awareness of whether there is room for a wheelchair to board a vehicle is extremely valuable to riders who use wheeled mobility devices. Therefore, the fullness reporting includes designation of four fullness levels (empty, seats available, standing room only, and full) as well as three wheelchair levels (room, not sure, no room). The separation is necessary since a wheelchair can fit onboard if there is room for people to stand when vacating the wheelchair parking area. The range in size of wheelchairs and scooters (D'Souza et al., 2010) suggests that a yes/no option for ratings of wheelchair room is too simplistic.

Figure 2. The user interface design showing arrival times, fullness, and messages for a specific stop (left) and the tagging interface for reporting (right)

Arrival and fullness data is accessed from bus stops, much like arrival time is found in AVL-based systems (e.g., NextBus; Ferris et al., 2010b). The screen for information at a stop (Figure 2, left) shows data for each bus as Scheduled, Historic, or Real Time. The latter occurs when a fellow user is collecting a trace. The middle case occurs when enough traces have been collected to provide a confident estimate based on historical patterns. The former case occurs when confidence does not meet threshold. Fullness is expressed similarly and specific icons are used to indicate wheelchair room. Recent messages logged by riders are shown with the bus data and the agency has the ability to push alerts to the trip banner at the top of the screen. Riders can begin tracing vehicles simply by pressing the “T” button next to each upcoming vehicle. There is potential for riders to abuse the fullness ratings. Users who intentionally over-rate fullness can be identified and filtered based on conflicting data from fellow riders and APC data.

Prior work suggests that location-aware selection of stops and routes is important (Ferris et al., 2010a) and this is supported through both map and list modes. List views are necessary for people who cannot use map interfaces easily. Another option is the ability to mark stops and routes as favorites for rapid retrieval. This is helpful for riders who have cognitive disabilities and/or limited dexterity and is useful for any rider who visits specific stops regularly.

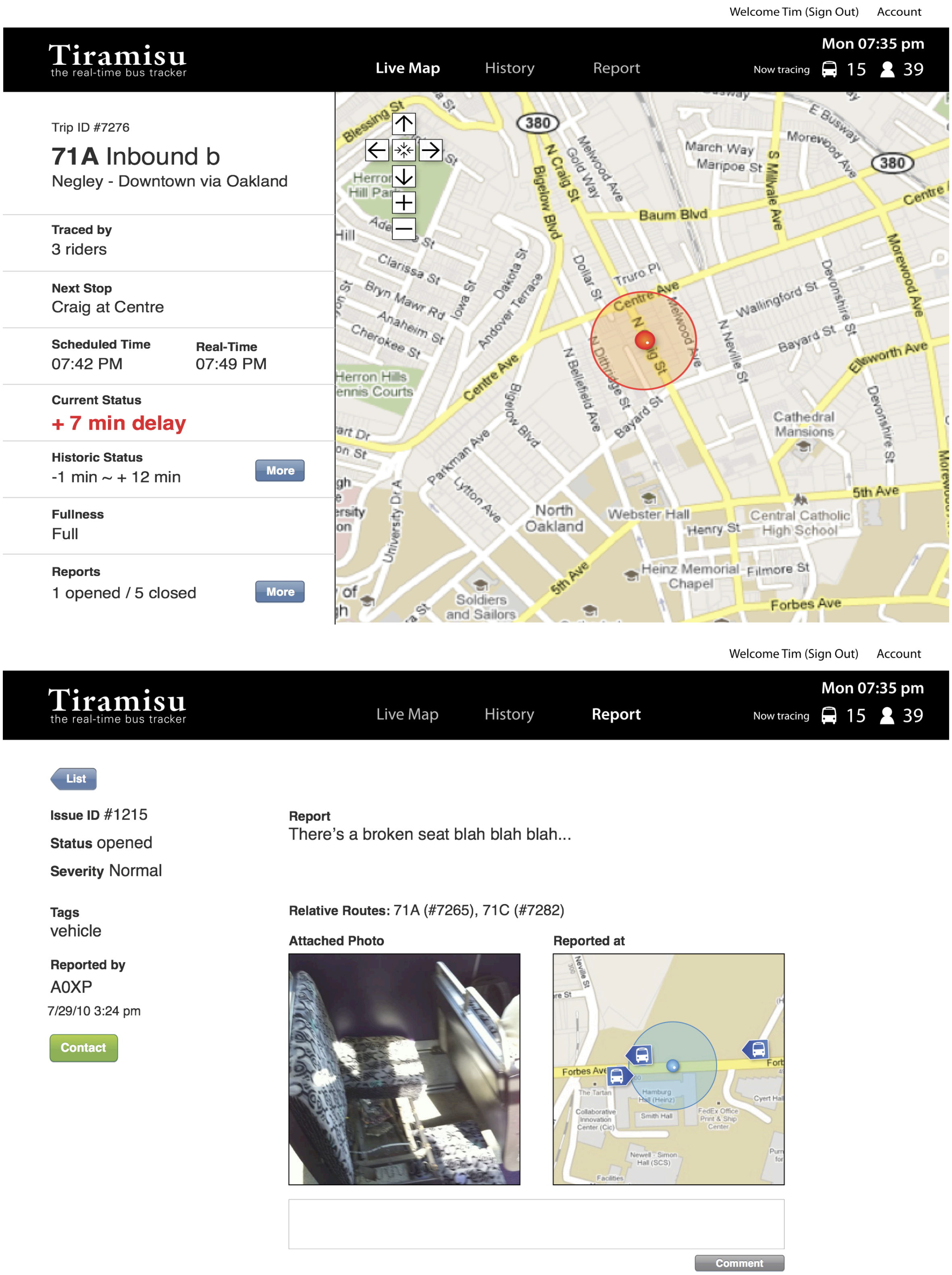

Figure 3. The designs for live tracking (top) and detailed report views (bottom)

When riders want to file a report related to a specific experience they simply press the Report button in the persistent navigation bar. This is primarily to support logging of accessibility barriers and positive experiences. However, in keeping with the focus on universal design, we have not constrained the single event reporting interface to this domain.

To streamline the interaction, the time, date, and rider location are recorded automatically and the first screen has simple yes/no toggles for classification (Figure 2, right). The next screen has a field for a text description of the problem and an optional attachment of a picture. Voice notes are also planned for users who prefer this alternative (Steinfeld et al., 2010a). Riders can also access their latest reports.

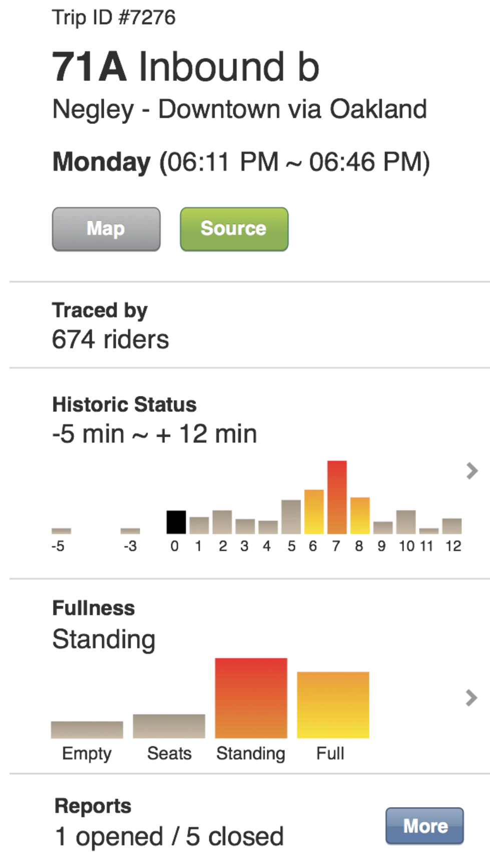

Figure 4. The design for the route history view

All designs are being implemented to support screen readers, both on the mobile client and web interfaces. However, not thinking about accessibility from the beginning can limit options during development. Therefore, the website for the system was designed from the wireframe stage to support accessibility features (Ayoob et al., 2010). In parallel, student course teams have developed a number of concept designs over the past year and some of the ideas generated by these teams are being incorporated into the project's core efforts. One student team interviewed participants from cities with real-time arrival systems and learned that riders like to keep webpages open while at home and work in order to time their departures more precisely. This has been incorporated into the design (Figure 3, top). The web interface can also be used by riders, agency staff, or other interested parties to see submitted reports and their current state (Figure 3, bottom). The same website will also support detail views of historical patterns. This has been highlighted by transit trainers as useful for finding routes appropriate for their clients (Figure 4).

Pilot Study

While the website and full feature set was being developed, an earlier version of the system was deployed and pilot tested as a closed beta (Zimmerman et al., submitted). Features like messaging were not present but real-time and historic data for fullness and arrival time and reporting were functional with a simplified version (Figure 5). The goal for this pilot was to find software bugs and improve algorithms, so riders with disabilities were not explicitly recruited and none participated. Having said this, accessibility is important to the team and even this preliminary version fully supported screen reading using the iPhone's VoiceOver feature.

The pilot included data from 28 people over a span of 38 days. Participants returned to after a few weeks to complete a survey and receive payment for their assistance. Riders were recruited from a specific region of the city to increase the chance their contributed data would directly benefit their fellow participants. This appeared to be the case and sampling of stops

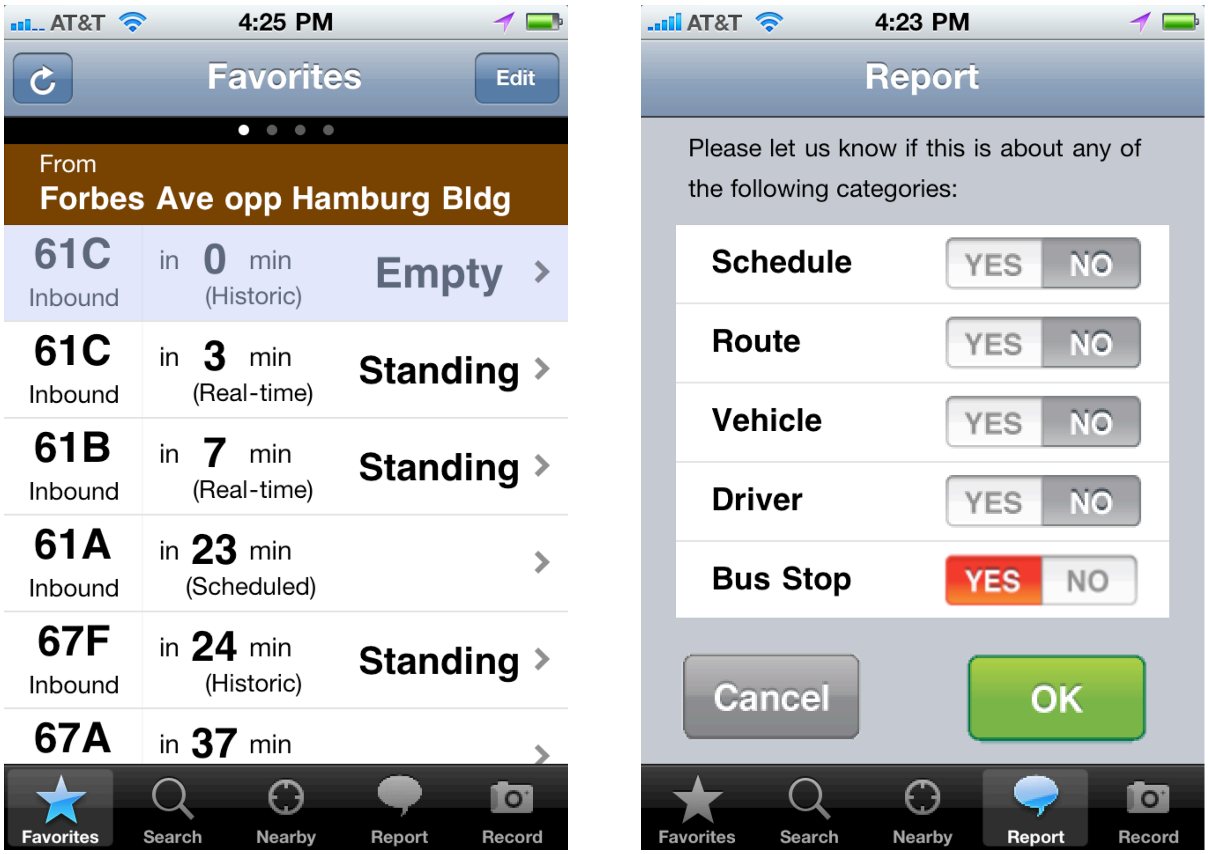

Figure 5. Example screenshots from the pilot version of the mobile client

within this transit corridor frequently revealed at least one real-time and several historic buses. Rider data was narrowed to 21 days each for analysis, with a focus on the 14 days prior to payment and 7 days after payment. Riders contributed data for 56% of the time when using the app. Individual rows in viewed arrival pages (e.g., Figure 5, left) shown to participants contained either historic or real-time data 13% of the time (2,132 out of 16,263). This is a very good rate, given the number of possible buses and the limited number of participants.

Participants in the pilot predominately reported issues with the system, which was expected and desired since this was a software beta test. However, 14 participants submitted a total of 22 reports specific to the transit system. In prior work (Steinfeld et al., 2010b), riders who use wheeled mobility devices reported at a much higher rate (58% or respondents) than their peers without disabilities (17%). The latter aligns well with the data seen in this pilot.

The pilot included exit interviews designed to inform design decisions related to end user motivation for sustained participation. Participants saw value in even this limited version of the system – almost all continued to use the app after payment. Some participants explicitly requested that we not delete the app during the interview and one changed their regular commute in order to catch a bus that was historically less full. A detailed analysis of the pilot study can be found in Zimmerman, et al (submitted).

DISCUSSION

This paper is intended to provide a summary of early Tiramisu development and provide context on why certain design decisions were made. Early testing of the system suggests our approach is potentially valuable enough for riders to commit time and effort into sustaining the envisioned user community. There are, however, issues that still need additional attention.

Methods for Routes With Low Ridership

The crowd-source model for tracking buses clearly will not work well if there is no crowd. Additional technology may be needed for rural transit agencies and routes with low ridership. Traditional AVL systems are still expensive for these cases. We have identified two low-cost methods for providing a minimum threshold of vehicle location data. First, colleagues have mounted commodity mobile phones on shuttle bus dashboards. Using a simple tracking application, the phones report their location to a central server for rider use (Carnegie Mellon University, 2009). Placing a Tiramisu equipped phone on a bus and having the driver start a trace at the beginning of each run is an obvious analog. Another approach is to use roadside detectors to document when buses pass key checkpoints. This is less effective but still provides potentially useful data. However, neither approach provides rider-contributed data and therefore limits the ability to establish and nurture a community of users. We are also exploring incentive models. It is easy to envision deals, discounts, and other approaches to motivate use.

Interaction Improvements

Our experience in the realm of machine learning systems for white-collar tasks (e.g., (Freed et al., 2008) leads us to believe that there are significant opportunities for streamlining various tasks related to data collection by riders, report handling by agency staff, and communication between all parties. However, it is important to design the interaction with machine learning carefully since improper user interaction can neutralize the potential for machine learning to make a positive impact (Steinfeld et al., 2007).

Evaluation

As stated, the pilot test was designed to identify system problems, inform design choices, and facilitate algorithm development for arrival estimates. Our research plan includes a full-community field test that will both test the system at a large scale and permit evaluation of system benefit and use. This process will begin soon, possibly before publication of this paper, with a public release of Tiramisu.

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