Experiments with a Public Transit Assistant for Blind Passengers

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Why Public Transit?

- Public transportation is a major key to independence, productivity, and community participation for people who are blind or severely visually impaired

[American Foundation for the Blind]
Why Public Transit?

• Yet independent use of public transportation is challenging for many potential users
  • E.g., people with visual or cognitive impairment

• Difficulties include:
  • identifying the bus stop or train track
  • getting into the right bus/car
  • understanding when to disembark from bus/car
A Personal Travel Assistant

- Idea: personalized travel information directly on the user’s cell phone

- User can access customized, just-in-time information via multiple modalities

- For example, users can:
  - be informed when a desired bus/train has arrived
  - obtain confirmation that they are on the right bus/car
  - specify the arrival bus stop/station, and be informed when the bus/train is approaching it
Previous Work

• GPS localization + Internet access to bus information
  • (Banatre et al., 2004)
  • (Azenkot et al., 2011)
    • Based on OneBusAway (Barbeau et al., 2010)
  • (Harrington et al., 2012)
    • Uses GTFS feeds

• Bluetooth beacons
  • (Lim et al., 2008)
Previous Work

Bluetooth beacons for accessible crosswalks (Bohonos et al. 2008)
Bus PTA Configuration

• Wi-Fi Access Points (AP) are placed at bus stations and inside bus vehicles

• Bus stop AP communicates:
  • Bus stop address and ID
  • Bus routes
  • Arrival times

• In-bus AP communicates:
  • Bus ID
  • Information about bus stops en route

This is the 16 bus
• Arriving at High St.
• No. of stops till destination
• Alert before desired stop

Buses stopping here
• Bus routes/schedules
• Arrival information
Hardware Components

- **Server:**
  - TP-LINK routers
  - Reprogrammed in OpenWrt
  - Routers configured as Wi-Fi AP with static IP address

- **Client:**
  - Nexus 7 tablet
  - Android app in Java
Static and Mobile AP

- Mobile in-bus APs may come within range of other in-bus APs or static bus stop APs
- Client must be able to handle these situations, and to decide whether to remain connected to an AP or to switch over to a newly encountered one
Transmission Range

- Transmission power: 500 mW
- Actual range: 64 meters
  - Client can detect AP but is unable to connect or transmit information
- Effective range: 50 meters
  - Client can connect, send information and remain connected
Connecting to an AP

- Sequence of tasks to successfully initiate a data communication:
  - Scan for APs
  - Connect
  - Exchange handshake information and data request
  - Remain connected or start scanning again
User Interface

- Input: multi-touch gesture interaction
- Output: synthetic speech

During **system-prompted interactions**, user navigates through lists of items (choices) using right/left swipes, then selects item via single tap
  - when user arrives at bus stop and needs to select AP

During **user-prompted interactions**, user taps screen and holds for 3 seconds, after which list of items is presented
  - when user wants to hear arrival times
  - when user is in bus and wants information about next stops

- Alerts:
  - Bus at ~20 meters from stop
  - When bus is reaching destination (2 bus stops away)
Info Exchange: Bus Stop

- Upon arrival at bus stop:
  - Client detects all APs in range
  - Prompts user to select a specific AP if multiple in range

- Bus stop AP transmits relevant info (AP location and bus routes)

- User is prompted to select bus line

- If available, arrival information is periodically transmitted

- Upon arrival of bus of selected lines, client disconnects from bus stop AP and connects to in-bus AP
  - To do: deal with multiple buses arriving at the same time
Info Exchange: In Bus

• User is informed that he/she is connected to in-bus AP

• User is prompted to select a destination bus stop from a list

• If desired, system may periodically update user about upcoming bus stops

• Upon request, system can remind user of the last bus stop traversed

• User is informed two stops in advance of arrival to destination bus stop, in time to get ready to exit the bus
User studies
Participants

- Four blind participants tested the system in February and March of 2015
  - Aged 55 – 64
  - Some used public transit regularly, some never used it
  - Two participants decided to use earphone

- Participants conducted two end-to-end transit tasks with assistance from our system
  - All participants completed tasks successfully
  - At the end of the trials, each participant participated in a semi-structured interview session
Interview with participants:
Main accessibility issues

• Finding which bus line to take and arrival times
• Catching the correct bus
• Determining when to exit the bus
• Bus stops difficult to locate
• Bus vehicles not pulling close enough to curb
Bus routes
Bus arriving at stop
Arriving at a bus stop
Interview with Participants: Comments and feedback

- Generally positive comments
- 2-stop-away warning appreciated by all participants
- Arriving bus alert appreciated, but should be activated earlier (e.g. 30-40 seconds before arrival)
- Tap-and-hold interface did not work well for two participants
Conclusions

- Location-based transit information system that does not require continuous internet connection and GPS usage
- Has potential for increasing independence and safety of travel for blind people
- Is it sustainable? Burden is on transit companies…
  - AP hardware is economical
  - Uses information readily available at bus and bus stop
  - No need to upload real-time info on internet
  - Could increase ridership
  - Can be useful for all passengers!
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