# Experiments with a Public Transit Assistant for Blind Passengers

G. Flores, R. Manduchi
University of California, Santa Cruz

# 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

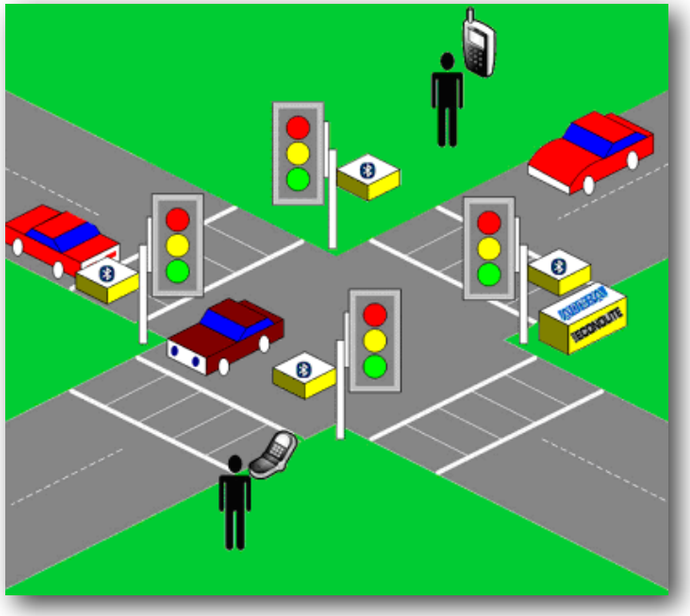
- Idea: personalized travel information directly on the user's cell phone
- User can access customized, just-in-time information via multiple modalities
- For example, users can:
  - be informed when a desired bus/train has arrived
  - obtain confirmation that they are on the right bus/car
  - specify 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 at al., 2011)
    - Based on OneBusAway (Barbeau et al., 2010)
  - (Harrington et all., 2012)
    - Uses GTFS feeds
- Bluetooth beacons
  - (Lim et al., 2008)

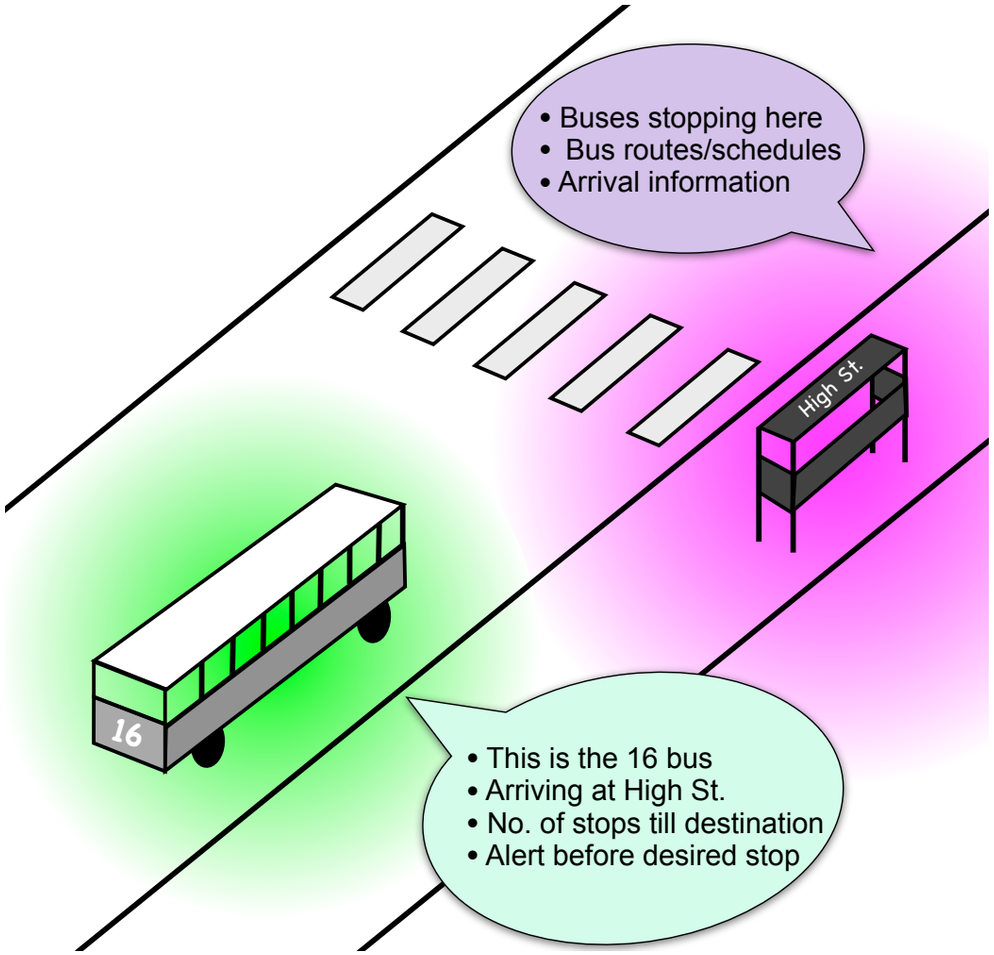
# Previos Work

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



# Hardware Components

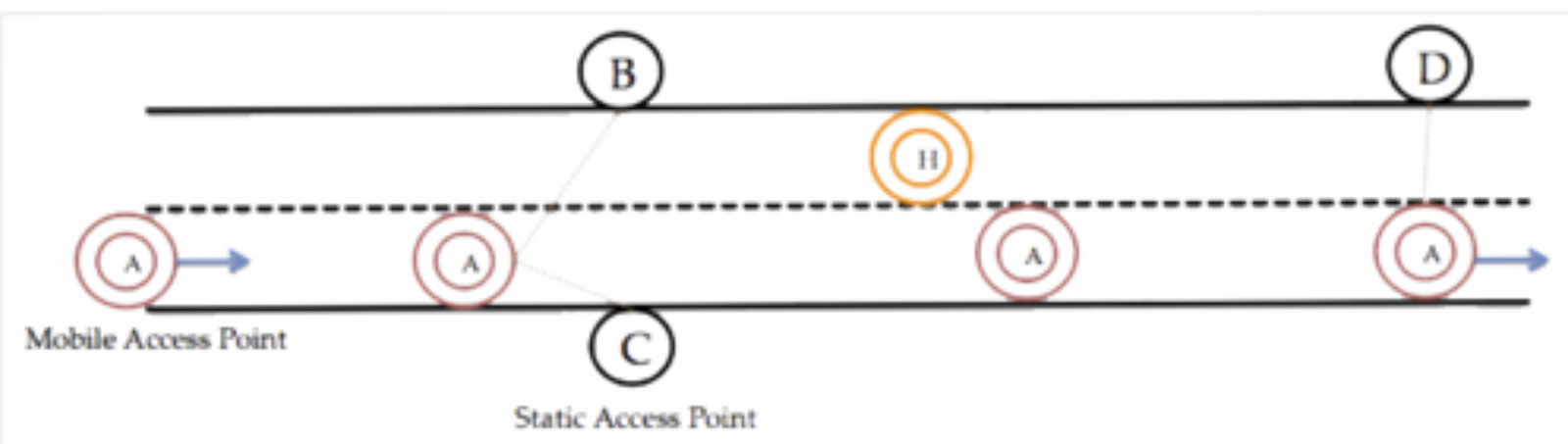
- Server:
  - TP-LINK routers
  - Reprogrammed in OpenWrt
  - Routers configured as Wi-Fi AP with static IP address



- Client:
  - Nexus 7 tablet
  - Android app in Java

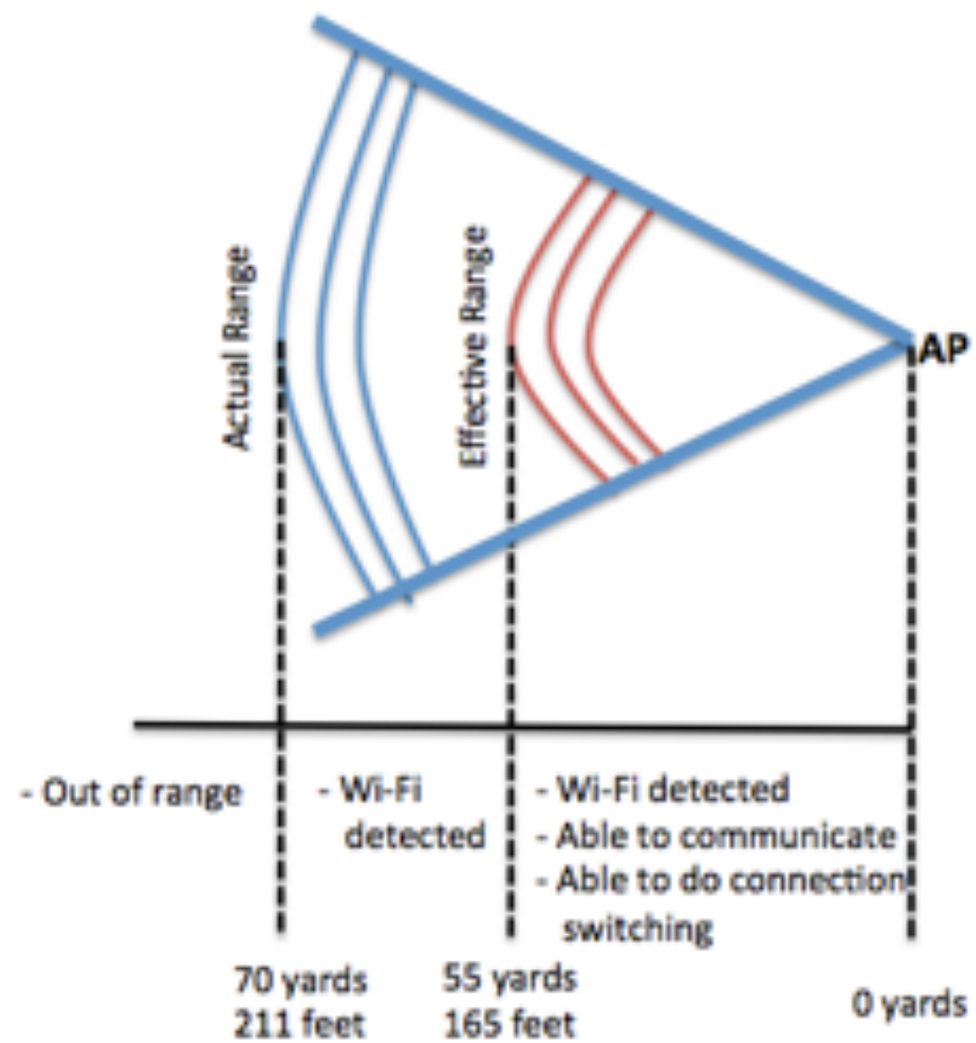
# Static and Mobile AP

- 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



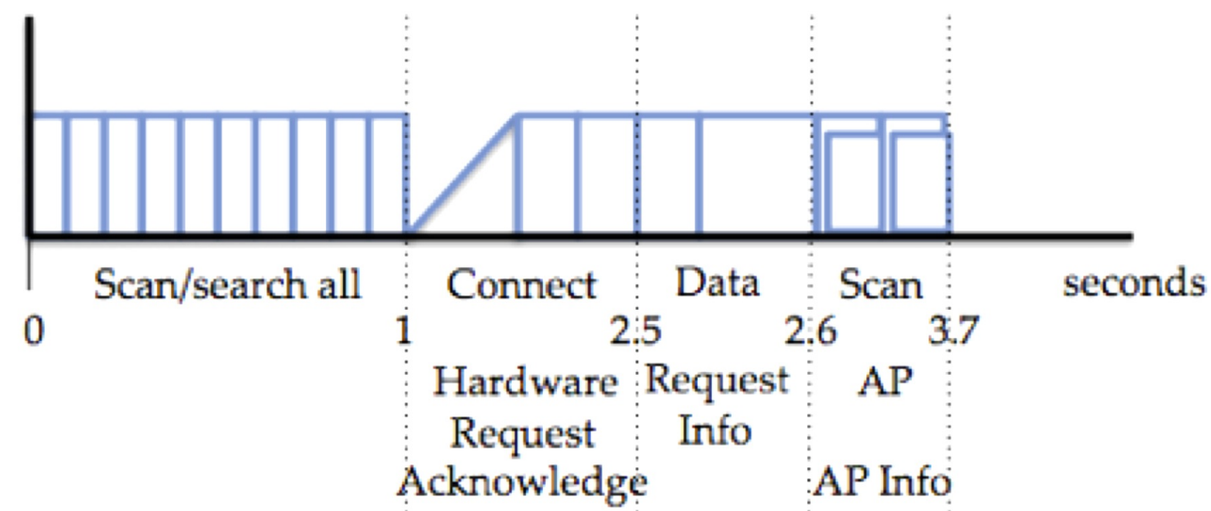
# Transmission Range

- 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 an 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

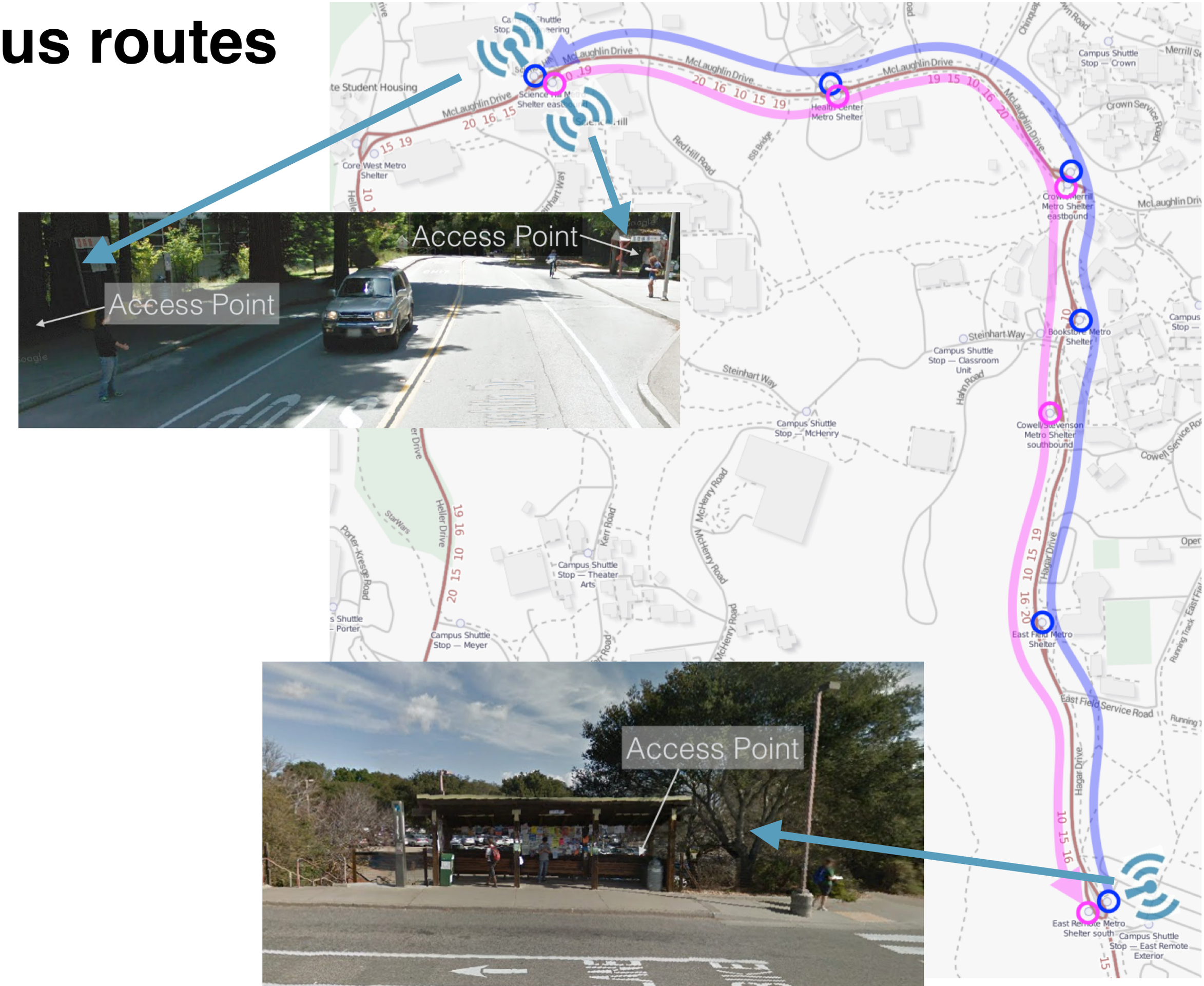
# Participants

- 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

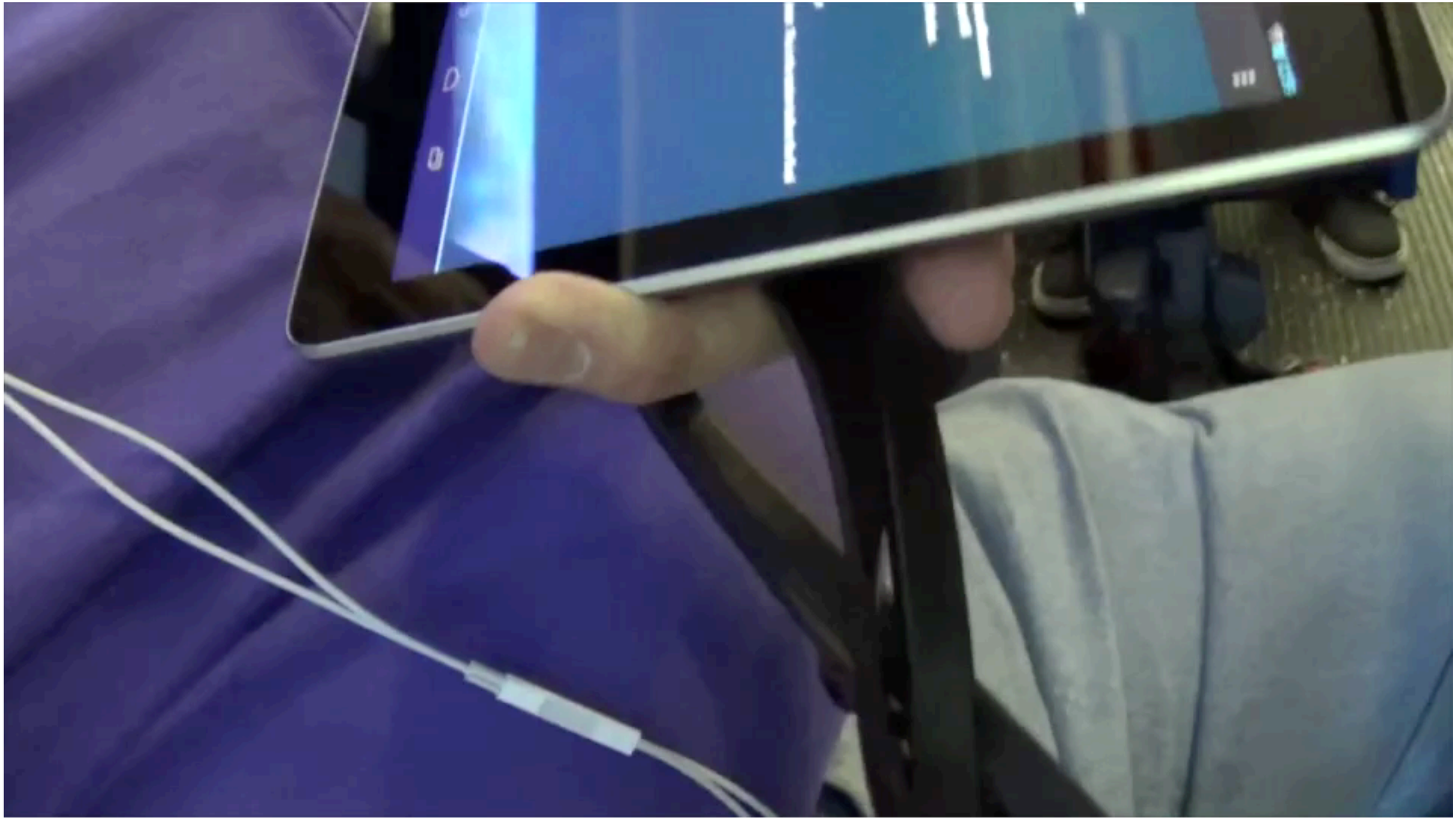
- Finding which bus line to take and arrival times
- Catching the correct bus
- Determining when to exit the bus
- Bus stops difficult to locate
- Bus vehicles not pulling close enough to curb

# Bus routes


Access Point
Access Point
Access Point
McLaughlin Drive
Science Hill Metro Shelter eastbound
Health Center Metro Shelter
Core West Metro Shelter
Crown/Merrill Metro Shelter eastbound
Campus Shuttle Stop — Crown
Bookstore Metro Shelter
Campus Shuttle Stop — Classroom Unit
Steinhart Way
Campus Shuttle Stop — McHenry
Cowell/Stevenson Metro Shelter southbound
Campus Shuttle Stop — Theater Arts
Campus Shuttle Stop — Meyer
East Field Metro Shelter
East Remote Metro Shelter south
Campus Shuttle Stop — East Remote Exterior
Hagar Drive
East Field Service Road
Heller Drive
Red Hill Road
Crown Service Road
Cowell Service Road
McHenry Road
Kerr Road
Porter-Kresge Road
Hahn Road
Chinquapin
Merrill
Steinhart Way

# 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!

# Acknowledgments


- Work sponsored by the Transportation Research Board under the IDEA program

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