

CityGuide: Beacon-Based Community-Driven Inclusive Wayfinding

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ABSTRACT

This extended abstract presents a long-term vision of a multi-disciplinary collaborative project to design, deploy, evaluate, and refine a smartphone-based city-wide wayfinding system called CityGuide in Wichita, KS, USA. CityGuide is envisioned to (i) complement outdoor GPS systems through the use of Bluetooth Low Energy (BLE) beacons to provide fine-grained, customized, turn-by-turn navigation within or across indoor and outdoor spaces for people with various disabilities in addition to the general population, and (ii) supplement existing signage by providing customized information about landmarks, transit stops, and other features of interest in the community. As a result, CityGuide is expected to contribute to improve the health, well-being, and safety of citizens and visitors to Wichita and beyond.

Author Keywords

Navigation, Wayfinding, Accessibility, Community, Wireless Networks, Mobile Computing

ACM Classification Keywords

H.5.2 User Interfaces: User-Centered Design; C.2.0 Computer-Communication Networks: General

MOTIVATION AND PROJECT GOAL

Wayfinding remains a challenge for people with disabilities in our communities. For outdoor environments, recent advances in satellite-based technologies (eg. GPS) along with the pervasiveness of smartphones provide an accurate and simple to use means for wayfinding. However, there remain many outdoor areas such as sidewalks, within and around office buildings, public recreational areas, and university campuses, where the effectiveness of satellite-based systems such as global positioning systems (GPS) is limited or non-existent. Furthermore,

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wayfinding remains a challenge in many indoor environments, especially those that are geographically large, such as grocery stores, airports, sports stadiums, office buildings, and hotels.

Reading and following signs remains the predominant mechanism for receiving wayfinding information in areas without GPS coverage. This puts people who are blind or visually impaired (BVI) at a great disadvantage. Similarly, for people with mobility impairments requiring the use of wheelchairs or walkers, the determination of accessible pathways to a destination remains inefficient by following visual cues. For example, upon entering indoor spaces, wheelchair-accessible paths are not always marked. Moreover, outdoor sidewalks do not typically indicate the absence of curbs and wheelchair accessibility. For older adults with cognitive impairments, it may be difficult to comprehend signage and find their way around in unfamiliar areas [11, 14]. Thus, *there still remains a great need to provide a low-cost, easy to use, and reliable wayfinding system within indoor and outdoor spaces that complements existing satellite-based systems*. A solution to this “auxiliary” wayfinding problem for people with disabilities in our communities also has broad applications for the rest of the general population in unfamiliar, disorienting spaces.

INCLUSIVE WAYFINDING THROUGH CITYGUIDE

CityGuide is envisioned as a smartphone app interacting with strategically placed BLE beacons used by the population of a community to access various location-based services (LBS) beyond what is possible with just a GPS-based system. CityGuide can complement a GPS navigation app by providing the following applications: (i) **Wayfinding**: This includes finding one’s way between two points within indoor spaces or outdoors where at least one of the points is not mapped well or covered by GPS apps, or from indoor locations to an outdoor location and vice-versa. The wayfinding application of CityGuide will include the ability to direct someone through an evacuation path in emergencies such as when a fire alarm or a tornado siren goes off, or when there are active shooter alerts at a workplace or school building. (ii) **Landmark Description**: There are limited budgets and space to add a lot of information on sculptures and other indoor or outdoor landmarks around the city. A beacon placed with every landmark can be programmed to contain detailed information about the

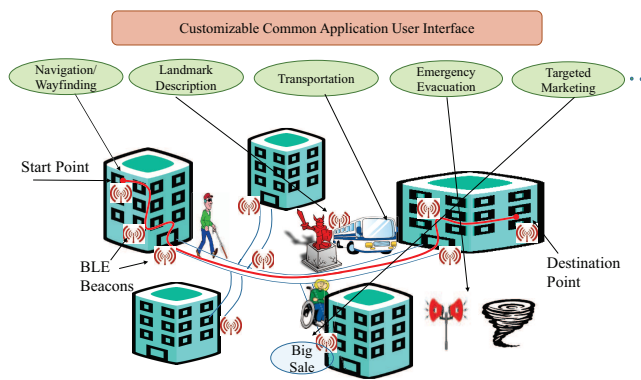


Figure 1: The CityGuide concept summary

landmark beyond what is provided on signage. (iii) **Transit:** In addition to locating and navigating to transit stops, CityGuide will provide non-visual information about the presence of transit vehicles within the vicinity of a user. Further, drivers of transit vehicles will be alerted about the presence of someone interested in boarding their vehicles.

CityGuide will initially define five (different but combinable) user categories: people who are blind or visually impaired (BVI), mobility impaired, cognitively impaired, users with no significant impairments, and older adults; older adults may have one or more of the impairments from the first three categories. Additional categories such as people with hearing impairments will be added at a future date.

POSITION IN LITERATURE

Auxiliary wayfinding solutions based on RFID or a system like TalkingSigns are not very flexible or require special hardware to be carried by the user [9, 13, 15, 8]. Other approaches providing remote assistance from others to navigate [1, 2] run counter to the preference for independent living. Recent work in developing systems for wayfinding use low-cost, stamp-size BLE “beacon” devices embedded in the environment that interact wirelessly with smartphones carried by users [10, 4, 7, 12, 6, 5, 3]. Many technical challenges in large-scale beacon placement and interaction with existing GPS-based systems still remain largely unaddressed. The biggest limitation of prior work may be that they have targeted just one disability that has resulted in the potential user base being very small. CityGuide has a goal to simultaneously address the unmet wayfinding needs of people with various disabilities in addition to the general population using a common technology infrastructure.

PLANNED METHODOLOGY

The top-level goal of using technology to improve accessibility in communities naturally requires integrative socio-technical research contributions. Such contributions include answering the following fundamental research questions: (i) how can location-based services (LBSs) be provided both indoors and outdoors seamlessly? (ii) what contextual information and cues should be provided with LBSs, with an emphasis on indoor wayfinding for users with one or more disabilities?

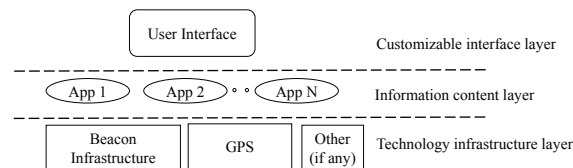


Figure 2: CityGuide concept shown as a three-layer model with lower layers serving the higher layers

and (iii) how can we design LBSs that are usable by all but account for the constraints imposed by the needs of some?. In addition, the effort will attempt to answer the following important question from a community planner’s perspective: how can this system and effort be sustainable long-term? This will require an economic analysis of the costs and benefits of such a system to a community and using that to determine an implementation pathway.

These contributions will be made within the framework of a layered architecture as shown in Figure 2. The beacon infrastructure is superimposed on the physical infrastructure strategically and provides the necessary auxiliary information (in addition to GPS) for various CityGuide applications to function. This project will use a BLE beacon infrastructure when available and fall back on the GPS system when no beacons are detected. Being a layered architecture, the upper layers can be agnostic of the lower layers and techniques employed; thus, different technologies could be used at the lower layer and still not impact the contributions at the upper layers and between them. The common user interface can be customized based on a user’s needs and preferences. For example, a person hard of hearing can choose to interact with applications through a text-based user interface, while someone who is visually impaired may prefer a voice and audio-based interaction. A person both visually impaired Figure 3. and hard of hearing may choose to interact through a tactile interface.

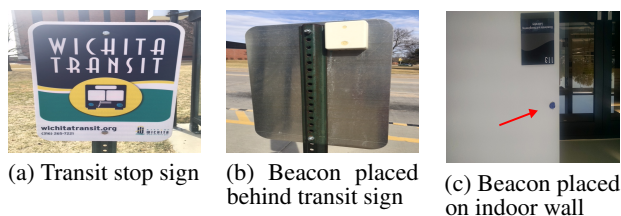


Figure 3: Images of beacon placements in Wichita.

Currently the CityGuide effort has already made progress on indoor wayfinding [10] (see Figure 3c.), beacon placement on all transit stops in the city of Wichita as shown in Figure 3a-b, and in prioritization of applications CityGuide should focus on initially through community stakeholder input gatherings.

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