Mobile Architectures and Prototypes to Assist Persons with Cognitive Disabilities using Public Transportation

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ABSTRACT

Public transportation systems are among the most ubiquitous and complex large-scale systems found in modern society. For those unable to drive, such as persons with cognitive disabilities or the elderly, these systems are essential gateways for participation in community activities, socialization, and independence. To understand the problems faced by public transportation users, our research team has (1) focused on systemic problems for persons with cognitive disabilities identified in a 1991 international public transportation survey by the National Research Council and (2) empirically assessed several public transportation systems to identify specific cognitive barriers that prevent people from learning and using these complex systems.

An interdisciplinary team of university researchers, urban transportation planners and managers, commercial technologists, and assistive care specialists are now collaborating to address these barriers. This collaboration has resulted in a Mobility-for-All architecture and prototype that demonstrates how intelligent mobile systems can interface with a real-time transportation infrastructure to provide contextualized and personalized "just in time" attention and memory prompts. This prototype demonstrates how support communities can use mobile technologies to train, assist, and assess the abilities of persons in their charge. This demonstration project provides both a near-term vision and an overarching architecture for transportation systems that are socially inclusive, technologically appealing, and easier for everyone to use.

BACKGROUND

A 2001 international survey of North American public transportation systems by the Transportation Research Board (TRB) in the National Research Council identified systemic deficiencies that prevent people with cognitive disabilities from learning and using mass transit systems. Public transportation system operators reported people with cognitive disabilities had problems reading and understanding directions, accessing the correct vehicle, exiting at the correct station or stop, and understanding announcements (3).

To identify specific cognitive barriers in public transportation systems, our research group conducted field surveys of bus, light rail, and subways in five major cities (Denver, Milwaukee, Chicago, Washington DC, and Tokyo). We also analyzed a "next generation" bus system in Vail, Colorado and Christ Church, New Zealand. Next generation systems commonly use mobile GPS and dynamic digital data displays at bus stops to provide real-time estimates for "next bus" arrivals while waiting.

STATEMENT OF THE PROBLEM

Our literature and field surveys identified *essential navigation artifacts* (Table 1) necessary to comprehend and navigate new routes. While conceptually simple, these artifacts are often difficult to comprehend and due to the need for procedural knowledge, attention, memory, and executive function skills (1). In field studies, we observed specialists struggle to teach teens with cognitive disabilities in a "school-to-work" transition program how to use these navigational tools.

artifact	purpose
maps	spatial relationships between one's current location and destination; identify routing options; provide an abstract means to assess overall trip progress.
schedules	temporal information about route availability at a given day and time.
landmarks	to confirm global progress and anticipate important events or tasks that will come next, such as prepare to get off, etc.
labels and signs	to understand the local environment, including: current location, where to meet transportation vehicles; identify the "right" vehicle; where to get on and off; where to pay; etc.
clocks	to synchronize schedules with physical events, including transportation vehicle arrivals and departures.

Table 1*: Essential navigation artifacts* found in public transportation systems

DESIGN APPROACH

We have designed a socio-technical architecture (Figure 1) to address the needs of mobile users traveling to and from a group home facility in a community setting managed by an assistive care specialist. This architecture leverages two emerging ubiquitous technologies: (1) mobile, wireless, location-aware personal digital assistants (PDAs) or phones, and (2) mobile GPS technology now appearing as "standard equipment" on new public transit vehicles.

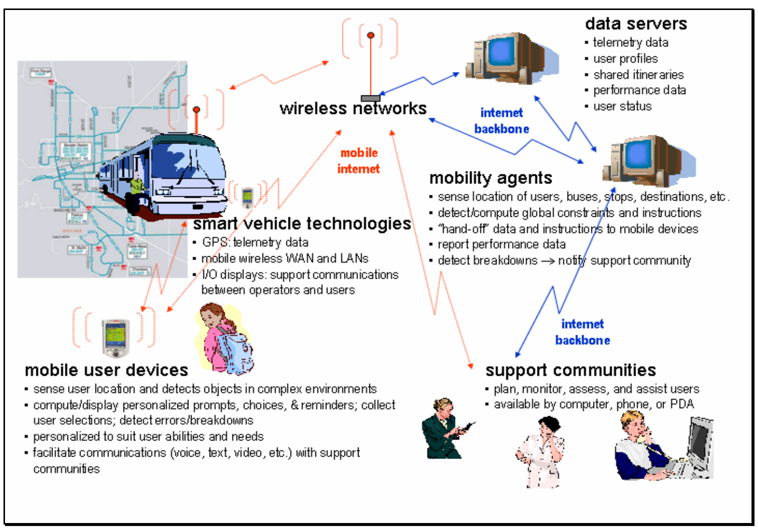

Figure 1: A proposed *architecture* to support mobile users and their support communities

PROTOTYPE SYSTEM COMPONENTS

As a proof-of-concept, we have developed a technical prototype that instantiates two synchronized architectural components (Figure 2):

1. *3D virtual real-time display for caregivers:* This component shows real-time location of buses, and a "virtual person" who responds to prompts from a simulated mobile prompting device (described in the following sections), allowing a caregiver to assess the progress of one or more mobile travelers (2).
2. *Simulated mobile prompting device (phone or PDA):* This prototype component provides personalized multi-modal (pictures, sound, movie, voice, and/or text) just-in-time prompts to a mobile user.

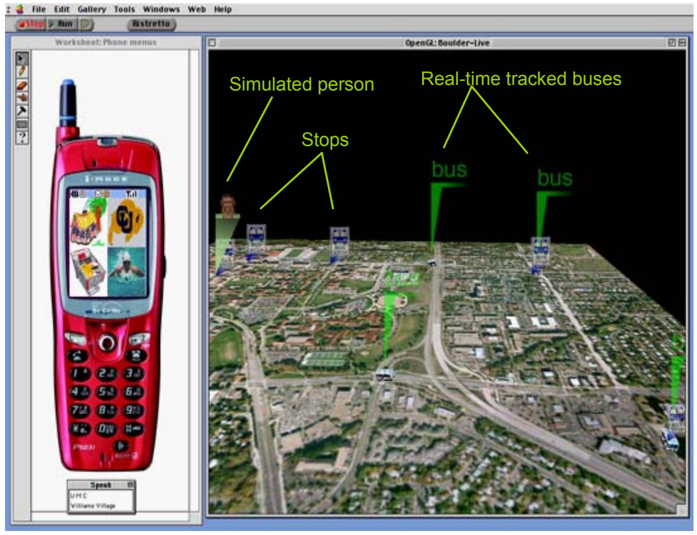

Figure 2: Agent-based prototype showing a mobile prompting device synchronized with a virtual 3D display of real-time bus system.

DISCUSSION

Our prototype instantiates key architectural components that link a mobile user with her support community. The person simulated in this prototype (Melanie) is assumed to be a teen with developmental disabilities resulting in attention and memory deficits. Melanie can be "directed" to a bus stop where a bus is approaching, and the demonstration sequence is "triggered" by selecting a destination options on her mobile phone/PDA. As the simulation runs, Melanie's mobile phone generates visual and auditory prompts triggered by real world events. Prompts are generated to "get ready" for her approaching bus, "please board now" when the bus stops at her location, "please pull the stop cord and prepare to get off" as the bus approaches the destination stop, "please get off" at the destination stop, and finally, "don't forget your backpack." As Melanie performs these tasks, she is also rewarded with reinforcing praise.

Our prototype demonstrates how intelligent, agent-based technologies can be designed to interface with a real-time data stream commonly available in GPS-enabled bus fleets, and it imposes no data loads on the real-time GPS bus management system since all computed events and prompts are simply used to update the mobile user.

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