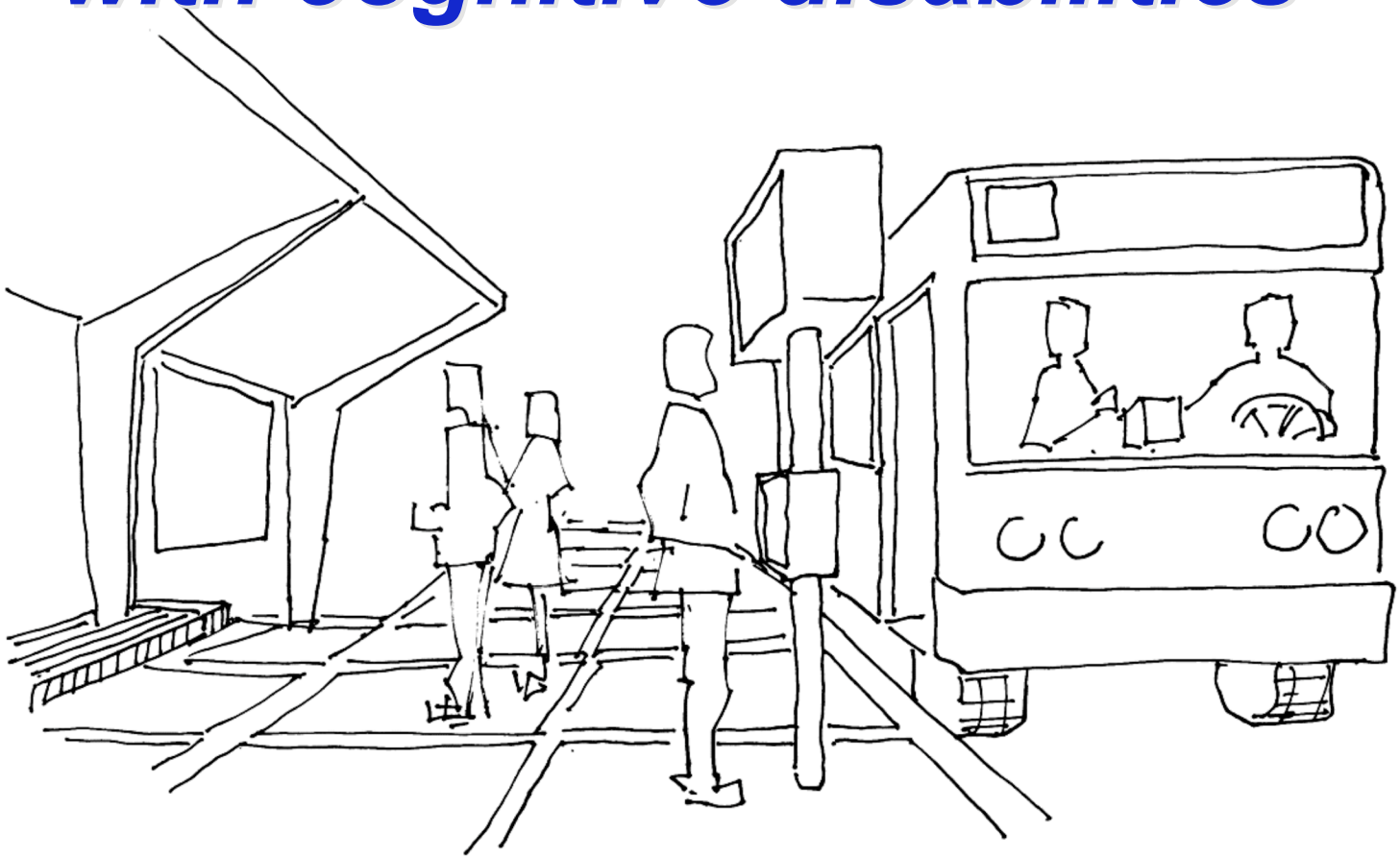
Transportation systems and people with cognitive disabilities



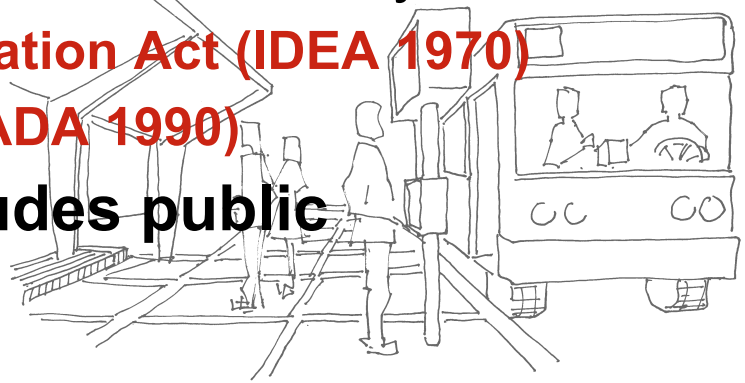
Dr. Jim Sullivan and Anja Kintsch
Cognitive Levers Project
Center for LifeLong Learning and Design
University of Colorado at Boulder
<sullivan> <anja>@cs.colorado.edu

Overview

- **current transportation systems**
  - demographic and public policy motivation
  - usage & costs: mainstream vs. para-transit systems
  - convenience issues
  - training programs
  - training prerequisites & themes
  - success rates
- **emerging technologies and opportunities**

Motivation

- **Demographics:**
  - ***7% or 20M US citizens*** with cognitive disabilities.
  - ***related demographics: rapidly growing elderly segment*** as population ages over next 30 years.
- **Public policy**
  - **movement from institutions** → public schools and *residential group home settings* over the last 35 years:
    - **Individuals with Disabilities Education Act (IDEA 1970)**
    - **Americans with Disabilities Act (ADA 1990)**
  - **ADA 1990 (Section 222) → includes public transportation systems …**



ADA 1990 section 222

Access to Public Services

"… it shall be considered discrimination … for a public entity which operates a fixed route system to purchase or lease a new bus, a new rapid rail vehicle, a new light rail vehicle, or any other new vehicle to be used on such system … if such bus, rail vehicle, or other vehicle is not readily *accessible* to and *usable* by individuals with disabilities …"

*Providing **accessible** and **usable** public transportation systems is not "optional"!*

Transportation usage & costs

- **sample system:** Denver Metro Regional Transportation District (RTD) Access-a-Ride Program
- **coverage**: 2,410 square miles in 38 municipalities
- **vehicles:** 1,176 vehicles
- **source:** RTD Para-transit Services

	RTD (2002)	**Access-a-Ride**
annual costs:	$288M	$20M **(7% of costs)**
annual rides:	81,322,365	465,272 **(0.6% of all rides)**
average cost per ride:	$3.54	$42.99 **(>12X average cost!)**
charge to travelers:	$.80 - $10.00	**2X regular fare**

Convenience

- **sample system:** Denver Metro Regional Transportation District (RTD)
- **source:** RTD Para-transit Services

	mainstream	**Access-a-Ride**
advanced scheduling & planning:	none needed	must be scheduled 4-7 days ***in advance***
pick-up:	according to a routine schedule	requires 30 min **"pick-up window"** at home & destination
other constraints:	pick-up/drop off only at fixed stops	must be within 3/4 mile of a fixed route

Travel training opportunities

- public school programs as required by Individuals with Disabilities in Education Act (IDEA) of 1970
- vocational rehabilitation services
- community independent living centers
- private developmental disability programs (Easter Seals, etc.)

Prerequisites for independent travel

- has permission from parents/guardians
- demonstrates purposeful motion
- aware of time
- able to get to the bus stop
- able to cross streets safely
- able to board correct bus
- pays correct amount
- aware of personal space
- deals appropriately with strangers
- recognizes and disembarks at correct stop
- knows when and who to ask for help
- recognizes danger
- follows directions
- can handle unexpected situations
- can use the telephone

All with 100% accuracy & consistency!

source: several training references, including 2001 National Research Council report by the National Transportation Research Board

Training themes and techniques

- **individualized plans**
- **labor-intensive training**
- **aid memory and focus attention**
- **practice & repetition**
- **solo rides with indirect observation**
- **emergency training**
- **verification & follow-up**

Sample visual training aides and tools

See Bus Number

Route 26 City Center

City Center	Beech St.	Pine St.	Post Office	Main St.
7:15	7:22	7:31	7:35	7:43
7:45	7:52	8:01	8:05	8:13
8:15	8:22	8:31	8:35	8:43
8:45	8:52	9:01	9:05	9:13
9:15	9:22	9:31	9:35	9:43
9:45	9:52	10:01	10:05	10:13
10:15	10:22	10:31	10:35	10:43
10:45	10:52	11:01	11:05	11:13
11:15	11:22	11:31	11:35	11:43
11:55	12:02	12:11	12:15	12:23

Plan Trip

In an Emergency, Bus Operator Will Call for Help

source: Easter Seals “Project Action” training document

Annual success rates in a NYC program over past 25 years

800 ***referred*** for training each year

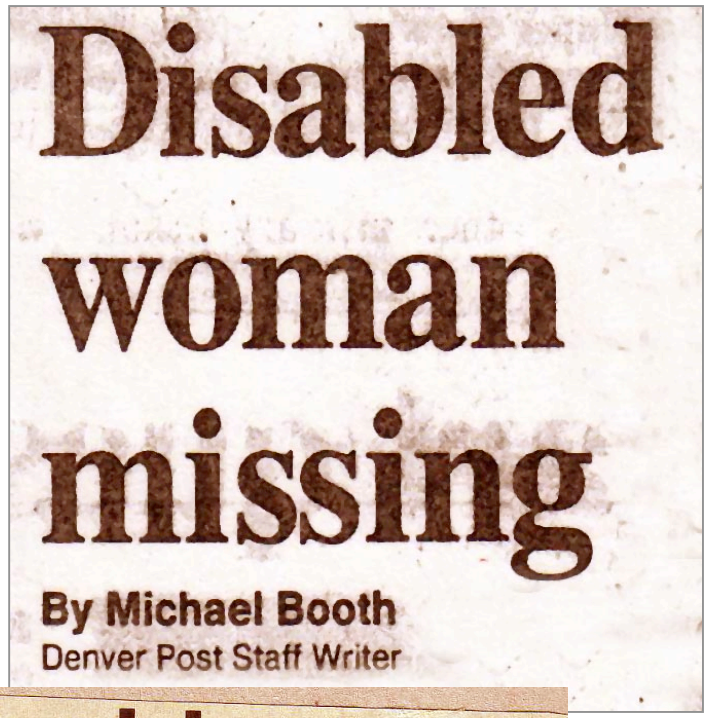
560 (70%) ***qualified*** for training

300 (38%) ***participate*** in 1:1 training

275 (34%) "***trained***" after 13 - 42 days

source: "Travel Training for Youth with Disabilities"
www.nichy.org/pubs/transum/ts9txt.htm

Do these headlines support “trust”?



Summary: problems with current transportation systems

- Public transportation systems are **essential** to those who cannot drive.
- But … many challenges exist:
  - **complexity:** public transportation systems are very difficult to understand, learn and use.
  - **expense:** para-transit systems are an order of magnitude more expensive than mainstream systems.
  - **convenience:** para-transit systems require advance scheduling and pick-up/drop-off windows; do not support ad-hoc travel.
  - **trust:** many are excluded because caregivers do not "trust" the system.
  - **social inclusion:** para-transit ≠ mainstream experience!

Emerging and converging technologies

- inexpensive **handheld personal computing and communication devices** (PDAs, mobile phones, etc.)
- precise **locational data** (i.e. GPS signals) in outdoor environments.
- **sensor data** from disparate sources, including “sensor networks”
- **network connectivity** everywhere …

http://mantis.cs.colorado.edu/

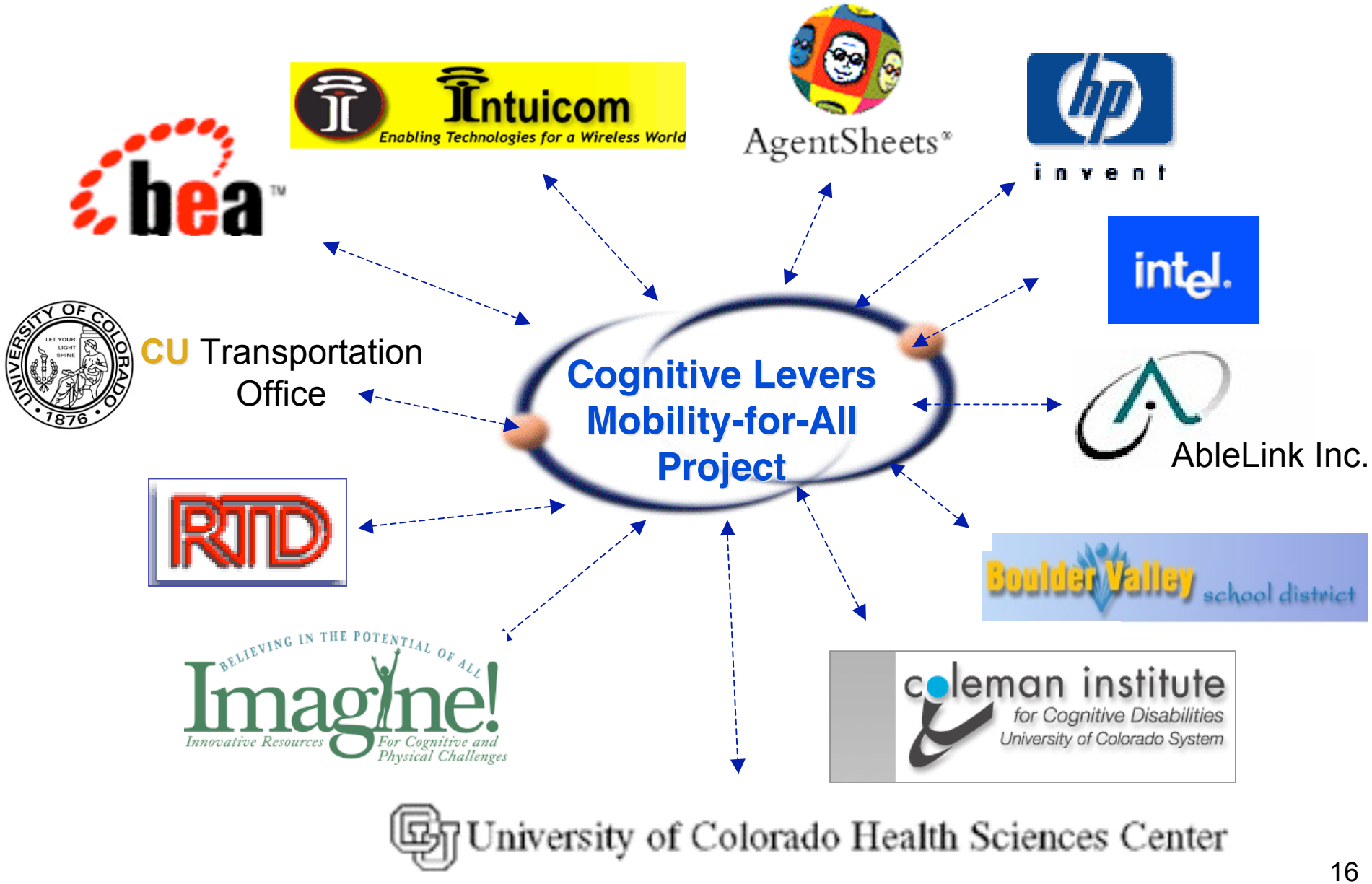
http://www.nextbus.com/

Research goals

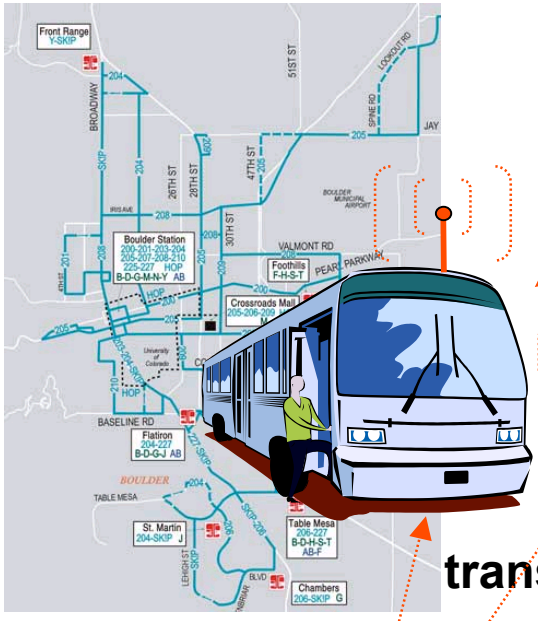
How can we design mobile, context-aware technologies to:

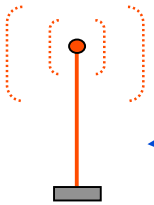
- **lower cognitive barriers** → reduce pre-requisite skills; provide individually contextualized support for what to do and where to go next;
- **reduce costs** → reduce time to learn systems; reduce/eliminate reliance on expensive para-transit system;
- **improve safety for travelers** → trap and respond to user and system errors; provide "panic button" support for travelers and accountability & trustworthiness for caregivers;
- **increase convenience** → eliminate the need for advanced scheduling and waiting for pick-up; support ad-hoc travel;
- **provide a more socially inclusive experience** → eliminate or reduce reliance on para-transit system.

project partners & collaborators

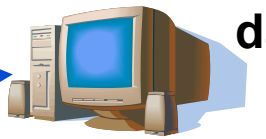


Mobile architecture

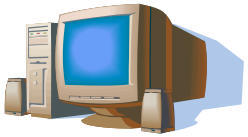




wireless networks



data servers



mobility agents

mobile internet

internet backbone

transportation systems

mobile users

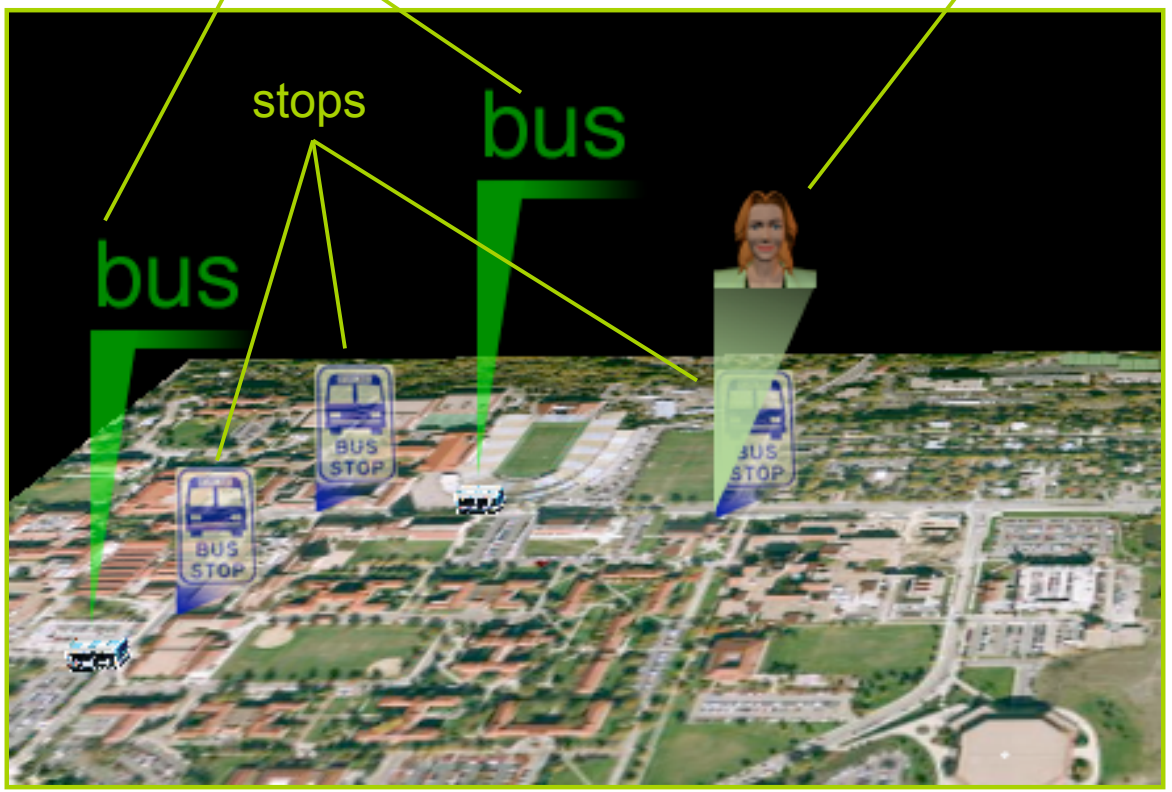
support communities

Mobility-for-All demonstration system

location-aware, mobile prompting device

real-time tracked buses

simulated person



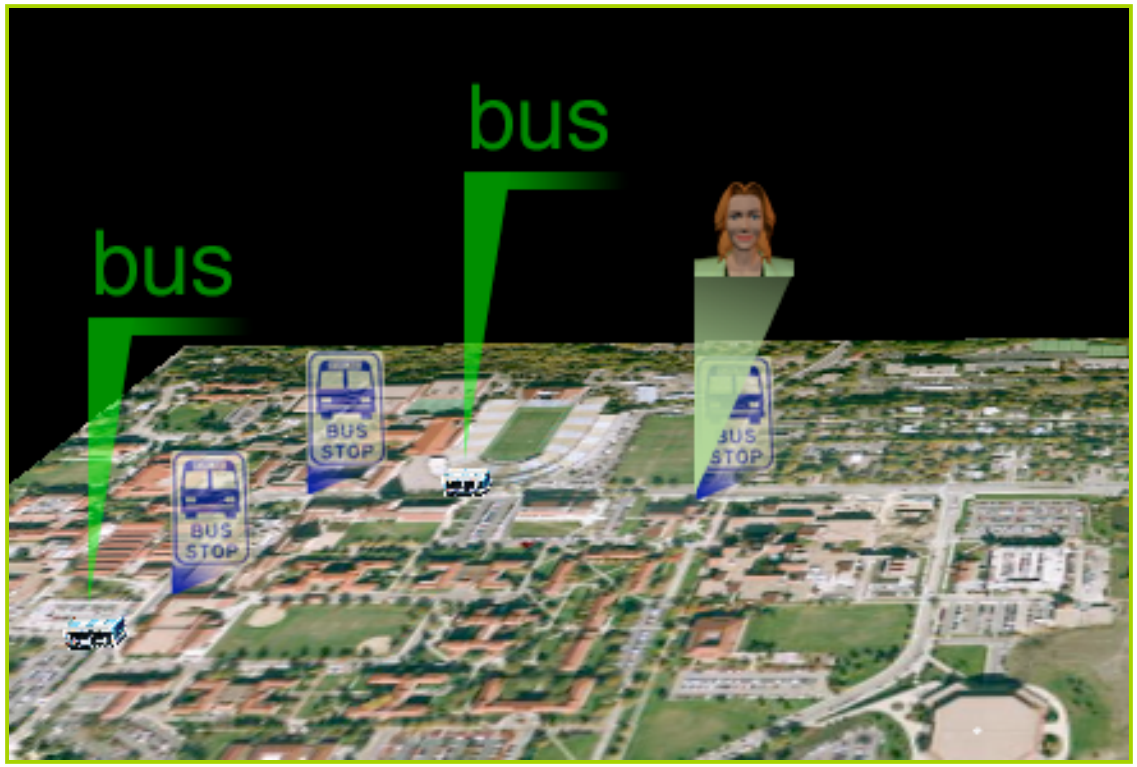
remote caregiver display

Mobile prompting system

Proof-of-concept of a **location-aware, mobile socio-technical prototype** with:

- ***personalized, logical choices*** (based on location, time of day and week, user abilities, etc.)
- ***essential information*** *from transportation infrastructure* - and potentially other web knowledge sources:
  - ✓ locate the "right" bus
  - ✓ prepare for boarding
  - ✓ get on the "right" bus
  - ✓ prepare to get off at the "right" location
  - ✓ reward good performance
  - ✓ help recall items easily forgotten in a complex itinerary
- ***multi-modal "just-in-time" attention and memory prompts*** based on user choices and actions.
- ***"safety net"*** *should something go wrong*

Caregiver 3D display



Before **travel:** ***route preparation*** **and** ***training***

During **travel:** ***real-time observation, error detection, and assistance to multiple travelers***

After **travel:** ***replay*** **and** ***assessment***

NSF SBIR Phase 1 Mobile Prototype

Goal: develop a mobile architecture and proof-of-concept mobile prototype using commercial off-the-shelf hardware.

Approach: team with industry hardware partners, transportation service providers and disability communities.

Key findings:

- mobile prototype developed on IPAQ 5455 with NavMan GPS sleeve, 802.11 wireless and Bluetooth/cell phone mobile network access
- no hardware platform exists **yet** with all needed capabilities (GPS, WAN, LAN, voice, bright touch screen display, ruggedized form factor, 4-6 hour battery life, etc.) **but** ….
- a cost-effective 24/7 "travel service" is key!

AgentSheets®

http://agentsheets.com/about_us/documents/mobility-agents.html

Future work

Goal	Approach	Research challenges
lower cognitive barriers	• eliminate/lower pre-requisite skills. • personalized, context-aware handhelds with multi-modal "just-in-time" attention & memory prompts.	• support customization by caregivers. • adaptive and adaptable behavior design. • support transfers and complex itineraries.
reduce costs	• leverage commercially available hardware & data network services. • use mainstream transportation. • reduce training times. • free caregivers from 1:1 verification.	• design a technically and economically feasible 24/7 "travel service" system. • availability of GPS and transmitters on bus lines?
improve safety	• panic-button support. • detect system & user errors. • caregiver display: – "situational awareness." – contextualized assistance.	• increase system and user reliability • eliminate "false positive" alarms. • safeguard personal information and privacy. • reduce non-detectable problems. • safety vs. privacy.
increase convenience	• use mainstream vehicles. • support "ad-hoc" travel.	• support traveler-initiated trips.
social inclusion	• use mainstream vehicles. • facilitate communications.	• detect potentially dangerous situations. • social skills may limit options.

Special acknowledgements

- ***Dr. Alexander Repenning, CTO AgentSheets Inc.*** Mobility-for-All prototype Co-developer & Mobility Agent SBIR Principal Investigator
- ***Intuicom, Inc.*** - mobile GPS equipment and data network for CU bus system
- ***Bryan Flansburg, CU Transportation Office*** - University of Colorado bus data

Sources

American with Disabilities Act of 1990, US Department of Justice website at: www.usdoj.gov/crt/ada/adahom1.htm

Braddock, D. (ed.) Disability at the Dawn of the 21st Century and State of the States. American Association on Mental Retardation, Washington DC 2002.

Center for Transportation Studies/ITS Institute – Specialized Transit and Elderly, Disabled, and families in Poverty Populations, found at: www.cts.umn.edu/pdf/CTS-01-03B.pdf

Denver, R.B. Community Living Skills: A Taxonomy, American Association on Mental Retardation, Washington D.C., 1988

Easter Seals "Project Action" training resources at: http://projectaction.easter-seals.org/site/DocServer/pictorial.pdf?docID=2625

National Organization on Disability *Transportation Access*, found at www.nod.org/transportation/index.cfm

Newbigging, E. D. (1996) "Riding the bus: Teaching an adult with a brain injury to use a transit system to travel independently to and from work," *Brain Injury*, 10(7), pp. 543-550.

NYC Travel Training Program report "Travel Training for Youth with Disabilities" found at: www.nichy.org/pubs/transum/ts9txt.htm

RTD facts and statistics: www.rtd-denver.com/

RTD Access-A-Ride program: www.specialtransit.org/ada.html

Snell, M.E. & Brown, F. Instruction of students with Severe Disabilities, 5th Edition Prentice Hall, Inc. New Jersey, 2000

Sullivan, J. and Fischer, G. "Mobile Architectures and Prototypes to Assist Persons with Cognitive Disabilities using Public Transportation," Proceedings of the 26th International Conference on Technology and Rehabilitation, Rehabilitation Society of North America (RESNA), Atlanta 2003.

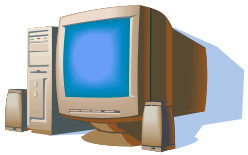
Transportation Research Board of the National Resource Council, *"Communicating with Persons with Disabilities in a Multimodal Transit Environment – a Synthesis of Transit Practices,"* (*TRCP report 37- 2001)* National Academy Press, Washington D.C. 2001.

Cognitive Levers Project

www.cs.colorado.edu/~l3d/clever
sullivan@cs.colorado.edu
anja@cs.colorado.edu

MFA architecture

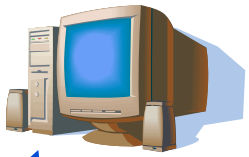
wireless networks



data servers

- telemetry data
- user profiles
- shared itineraries
- performance data
- user status

internet backbone



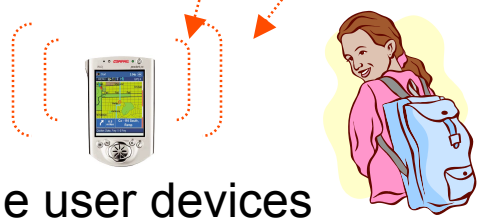
mobile internet

mobility agents

- sense location of users, buses, stops, destinations, etc.
- detect/compute global constraints and instructions
- “hand-off” data and instructions to mobile devices
- report performance data
- detect breakdowns notify support community

smart vehicle technologies

- GPS: telemetry data
- mobile wireless WAN and LANs
- I/O displays: support communications between operators and users



internet backbone

mobile user devices

- sense user location and detects objects in complex environments
- compute/display personalized prompts, choices, & reminders; collect user selections; detect errors/breakdowns
- personalized to suit user abilities and needs
- facilitate communications (voice, text, video, etc.) with support communities

support communities

- plan, monitor, assess, and assist users
- available by computer, phone, or PDA

Prototype technologies

private mobile WAN

900mhz (115.2 kbps)

GPS data server

internet backbone

GPS & WAN data transmitter

commercial or private mobile WAN

mobility agents & data servers

prototype wireless bus I/O device with wireless LAN (BlueTooth; 802.11, etc.)

mobile LAN network

- Commercial:
  - Cellular Digital Packet Data (CDPD) (19.2kbps): exs: PocketNet,Teletype.com, AutoDesk
  - Analog cellular (AMPS, etc)
  - -GSM/GPRS
- Private: (ex: Intuicom 115.2 kbps.)

internet backbone

support communities

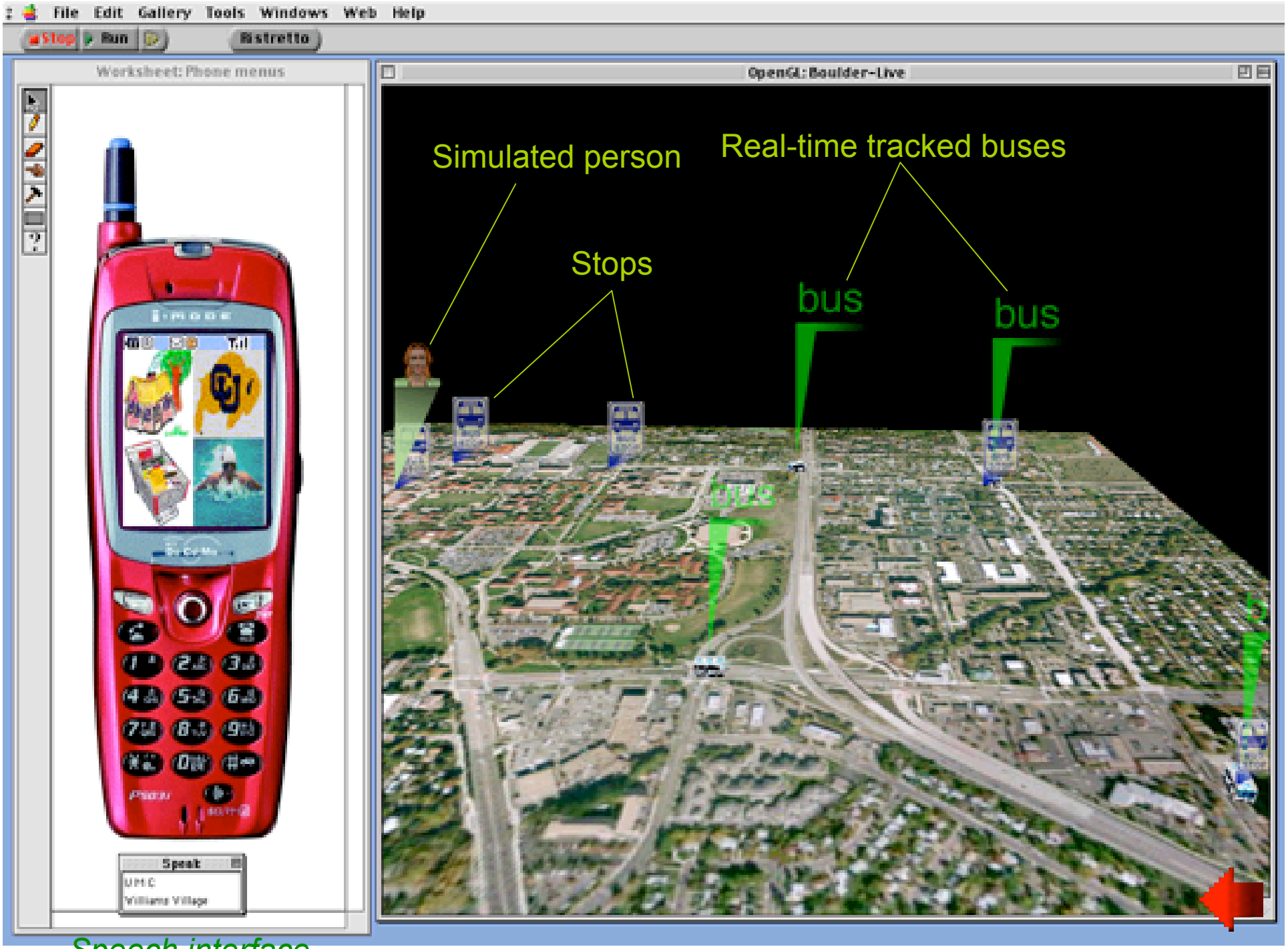
prototype mobile user device

- CPU & I/O device (PDA or laptop)
- GPS receiver
- Cell phone
- Mobile WAN (CDPD, AMPS, GSM/GPRS, etc.)
- Mobile LAN (BlueTooth, 802.11, etc.)
- 'SmartTag' sensor

cell phone & PDAs:

- internet capable
- support email or simple message service (SMS)

Email, phone, VoIP alerts



Speech interface

Component synchronization