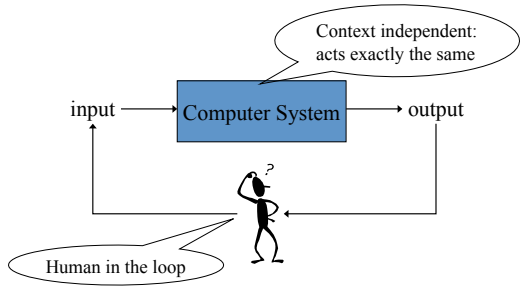
Context-Aware Computing

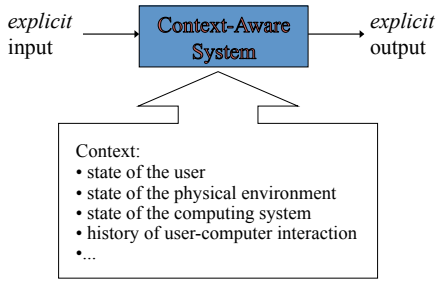
Traditional Computer View



From Abstraction to Context Sensitivity

- Traditional black box view comes from the desire for abstraction
- This is based on several assumptions:
  - Explicit input/output: slow, intrusive, requiring user attention
  - Sequential input-output loop
- Move away from the black box model and into context-sensitivity
  - human out-of-the-loop (as much as possible)
  - reduce explicit interaction (as much as possible)

Context as Implicit Input/Output



Context-Aware Computing

- Let computer systems sense automatically, remember history, and adapt to changing situations

- Identity, activity, feeling/mood
- Spatial: location, orientation, speed
- Temporal: date, time of day, season
- Environmental: temperature, light, noise
- Social: people nearby, activity, calendar
- Resources: nearby, availability
- Physiological: blood pressure, heart rate, tone of voice

Challenges

- Obtaining information needed to function
- How to represent context internally? How to combine it with system and application state? Where to store?
- How often to update and consult context information?
- What services does infrastructure have to provide?
- How to track location and sense surroundings?

Why Context-Aware Computing?

Existing Examples	Context Types	Human Concern
Auto Lights On / Off	Room Activity	Convenience
File Systems	Personal Identity & Time	Finding Info
Calendar Reminders	Time	Memory
Smoke Alarm	Room Activity	Safety
Barcode Scanners	Object Identity	Efficiency

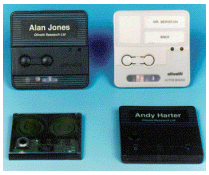
Why Context-Aware Computing?

Potential Examples	Context Types	Human Concern
Auto Cell Phone Off In Meetings	Identity	Convenience
Tag Photos	Time	Finding Info
Proximal Reminders	Location	Memory
Health Alert	Proximity	Safety
Service Fleet Dispatching	Activity	Efficiency
	History	
	…	

Why Context-Aware Computing?

- Presentation of information/services to a user according to current context
- Automatic execution of a service when in a certain context
- Tagging context to information for later retrieval

Example: Active Badges

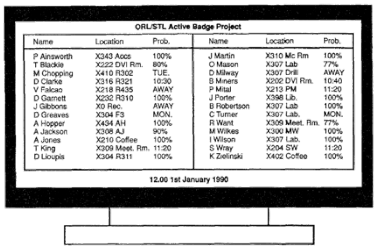


Active Badge

- Badges emit infrared signals
  - Provide rough location + ID
- Teleport
  - Redirect screen output from "home" computer to nearby computer
- Phone forwarding
  - Automatically forward phone calls to nearest phone

Example: Active Badges

- Interface follow-me (location)



ORL/STL Active Badge Project

Name	Location	Prob.	Name	Location	Prob.
P Ainsworth	X343 Apcs	100%	J Martin	X310 Mc Rm	100%
T Blackie	X322 DVI Rm.	80%	C Mason	X307 Lab	77%
M Chopping	X410 R302	TUE.	D Milway	X307 Drill	AWAY
D Clarke	X316 R321	10:30	B Miners	X202 DVI Rm.	10:40
V Falcao	X218 R435	AWAY	P Mital	X213 PM	11:20
D Garnett	X232 R310	100%	J Porter	X398 Lib.	100%
J Gibbons	X0 Rec.	AWAY	B Robertson	X307 Lab	100%
D Greaves	X304 F3	MON.	C Turner	X307 Lab.	MON.
A Hopper	X434 AH	100%	R Want	X305 Meet. Rm.	77%
A Jackson	X308 AJ	90%	M Wilkes	X300 MW	100%
A Jones	X210 Coffee	100%	I Wilson	X307 Lab.	100%
T King	X309 Meet. Rm.	11:20	S Wray	X204 SW	11:20
D Lioupis	X304 R311	100%	K Zielinski	X402 Coffee	100%

12.00 1st January 1990

Example: ParcTab

ParcTabs

- Active badge + wireless
  - Rough location + ID
  - Showing information of the room the user is in
  - Help find resources
  - Show all files in a directory when entering a room
  - Locate others
  - Different control choices in different rooms

(location, time, nearby devices, file system state)

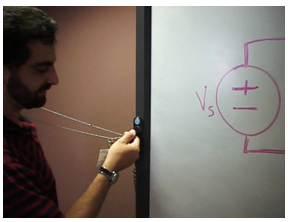
Auto-Diaries and Proximate Selection

Name	Room	Distance
caps	35-2-2-00	200ft
claudia	35-2-1-08	30ft
perfector	35-2-3-01	20ft
snoball	35-2-1-03	100ft

In/Out Board (Georgia Tech)

DUMMBO (Georgia Tech)

- Dynamic Ubiquitous Mobile Meeting Board:
  - Digitizing whiteboard to capture and access informal and spontaneous meetings
  - Capture ink written to and erased from whiteboard, and audio discussion
  - Activated when two or more people gathered around
  - Context: ID, time, location of whiteboard

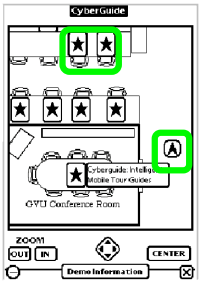


CyberGuide (Georgia Tech)

Cyberguide

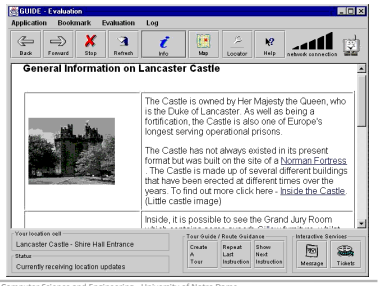
- GPS or infrared tracking
  - Fairly precise location
- Display location on screen
- Predefined points of interest
  - Automatically pop up if nearby
- Travel journal
  - Keep log of places seen and photographs taken
- Context: location, time

CyberGuide



GUIDE (Univ. of Lancaster)

- Context: location through WLAN, user preference

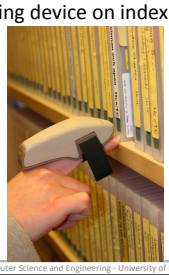


Encourage Healthy Dietary Behaviors

- Interactive game to assist teachers to improve dietary behaviors of kindergarten children ("smart lunch tray")

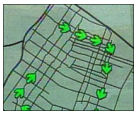
AudioIndex

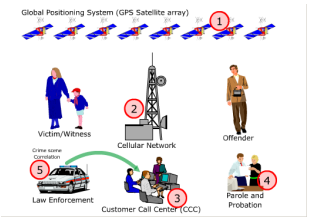
- Allowing visually impaired to browse and search audio books. Main device around neck, earpiece with audio feedback, pointing device on index finger.



Emergency Medical Response

Protech Parolee Monitor





Parent Pager

- A “child safety product”
- Activates an alarm when a child wanders more than 15 feet from the adult “base” unit
- Also alarms if submerged in water

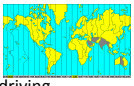
Garmin’s Rhino GPS + FRS

- Garmin's Rino GPS Radio gives users the ability to beam their location to other Rino users within a two-mile range and carry on conversations at the same time.

Context-Aware Communication

- Communication is a killer app for ubicomp
- Example activities:
  - Staying in touch
  - Coordinating with friends and family
  - Being aware of activities of friends and family
- Non-ubicomp evidence
  - Popularity of Social Networking web sites
  - Popularity of sharing sites
  - Popularity of blogs and message boards

Problems with Keeping in Touch



- Irrelevant messages
  - Vacation mail, surveys, junk email
- Interruptions
  - During meetings, concerts, movies, dinner, driving

- Lack of awareness on callee side
  - Phone tag, time zone issue
- Information overload
  - Can make it hard to find useful messages (e.g., delayed flight)

- Device overload
  - Fax, email, landline phone, mobile phone, IM

Context-Aware Communication

- Main idea:
  - Use sensors and other pieces of context…
  - to improve awareness of and communication with others…
  - while minimizing overload, irrelevancy, and interruptions

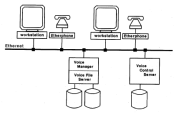
Context-Aware Communication

- Apply knowledge of people's context (and activities) to reduce person-to-person communication barriers
- Subset of Context-Aware Computing
  - Does not include, e.g., control of environment, or apps that filter information about nearby restaurants and printers
- Information versus communication
  - Is the chirping Lovegety an information or communication device?

Example: Routing

- Directing communication to nearby & appropriate devices (ubiquitous message delivery)
- PARC's Etherphone system
- Olivetti's Active Badge aiding a telephone receptionist

PARC Etherphone

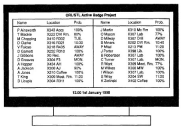


1

2

- 50 Etherphones
- Location registered by
  - Logging in
  - "Visiting"
- Distinctive ring tones

ORL Active Badge "Aid to a Receptionist"



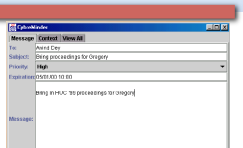
- Infrared emitting badges and network of receivers
- Initial application was an "aid for a telephone receptionist"
- Give a person info for tracking down callee

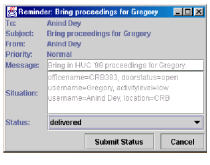
Context-Aware Mailing List

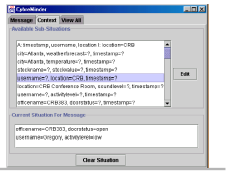
- In-out board using RF tags
- Dynamic e-mail list for directing email to people who are in the building
  - "let's get lunch"
  - "talk in 5 minutes"

CybreMinder

- To-do items associated with location and context
- Can be sent to other people
- Context include "forecast is for rain and Bob is leaving home."







Audio Aura

- Auditory cues as people walk around an office place
- Going to an empty office creates an audio cue about how long it has been empty
- A "group pulse" if people are meeting
  - Automated sensing
  - Little automated communication

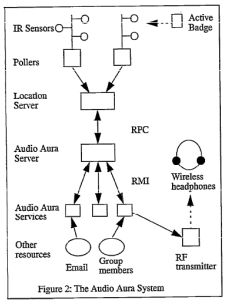


Figure 2: The Audio Aura System

Calls.Calm

- Calls.Calm uses web phones to mediate communication with subscribers.
- A person (a) selects who to call and
- (b) is greeted by the callees contact page *contextualized* and *customized for the caller*; or if the caller is unknown,
- (c) a generic page.

5 Design Considerations

1. Improving relevance
   - Deciding when a communication is relevant to the person's current (or near future) situation.
   - For example, getting notification about an email from your travel agent regarding itinerary changes while packing to leave for the airport.
2. Minimizing disruption
3. Improving awareness
4. Reducing overload
5. Selecting channels

5 Design Considerations

1. Improving relevance
2. Minimizing disruption
   - Deciding when and how to notify people that they have a communication.
   - For example, your phone should vibrate and not ring, when you are at the symphony (unless it is truly urgent).
3. Improving awareness
4. Reducing overload
5. Selecting channels

5 Design Considerations

1. Improving relevance
2. Minimizing disruption
3. Improving awareness
   - Deciding what information and mechanisms can help people make intelligent communication decisions.
   - For example, the caller should be told you are at the movies before the call goes through.
4. Reducing overload
5. Selecting channels

5 Design Considerations

1. Improving relevance
2. Minimizing disruption
3. Improving awareness
4. Reducing overload
   - Deciding how to reduce the number of communications that don't apply given your context.
   - For example, filtering out emails about going to lunch when you are away from the office (or already at lunch).
5. Selecting channels

5 Design Considerations

1. Improving relevance
2. Minimizing disruption
3. Improving awareness
4. Reducing overload
5. Selecting channels
   - Deciding which communication device should be used to get in touch with somebody.
   - For example, routing calls to your home phone instead of your cell phone when you are at home and cellular reception is poor.