



Pervasive and Context-Aware Computing

Sumir Chandra

ECE 572: Grid & Pervasive Computing

Spring 2003



Outline

- Context-Aware Computing Applications
 - Proximate Selection, Automatic Contextual Reconfiguration
 - Contextual Information & Commands, Context-Triggered Actions
- Project Aura: Distraction-free Pervasive Computing
 - Architecture
 - Cyber Foraging
 - Bandwidth Advisor, People Locator
 - Capturing User Intent
 - PHD, Idealink

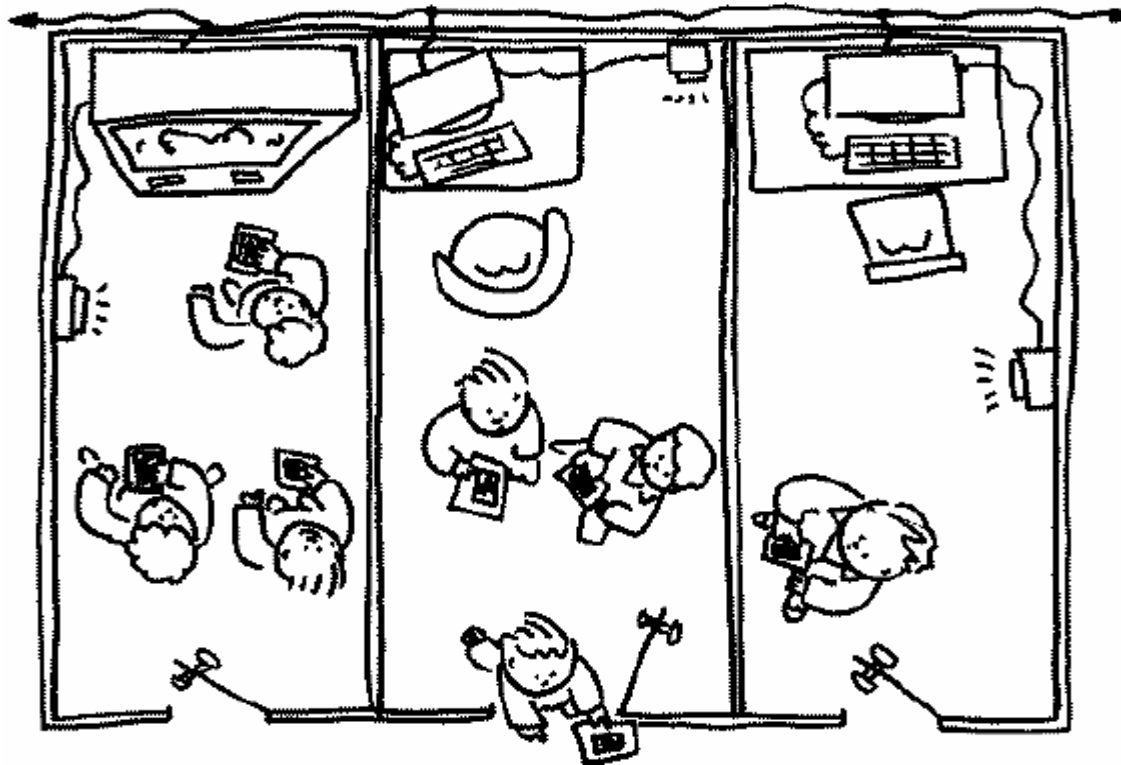


Context-Aware Computing Applications

- Columbia University & Palo Alto Research Center
- PARCTab – wireless, palm-sized computer
- Proximate environment of user is important
- Mobile distributed computing system
 - Collection of mobile and stationary computing devices that are communicating and cooperating on user's behalf
 - Ubiquitous access to information, communication, computation
- Context-aware systems
 - Adapt according to location of use, collection of nearby people, hosts and accessible devices, and their changes over time
 - Examine computing environment and react to changes

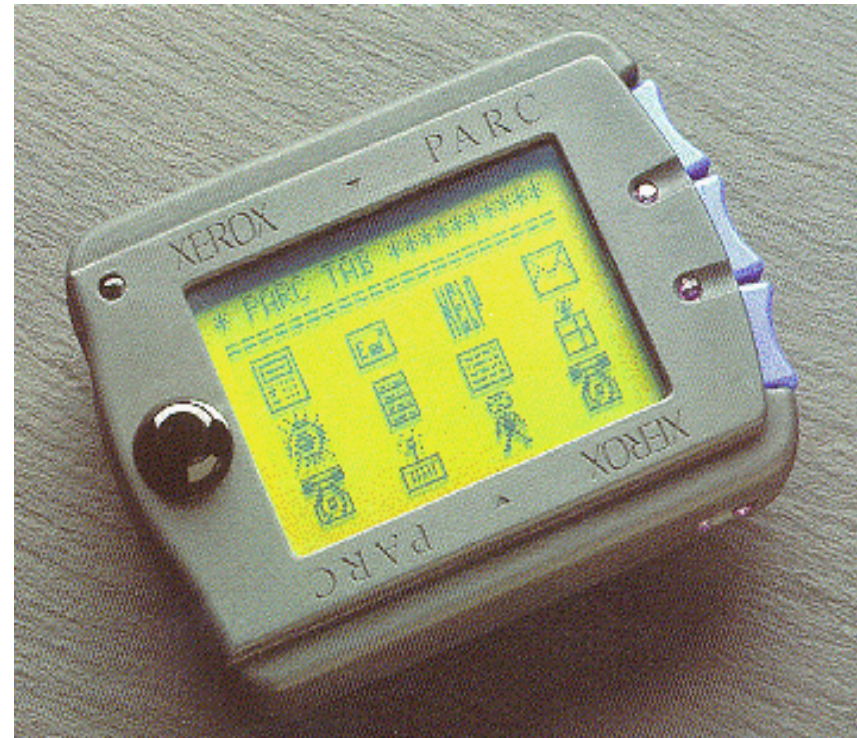
What is Context?

- 3 aspects
 - where you are, who you are with, what resources are nearby



PARCTab

- Hand-held device uses infrared cellular network for communication
- Tab acts as graphics terminal and applications run on remote hosts
- Input – 3 buttons and touch-sensitive screen
- Output – 128*64 pixel display and piezo-electric speaker
- Total bandwidth for all tabs in a cell is 19.2 kbps
- Location monitoring: tabs send identifying packets (beacons)





Context-Aware Categories

- Product of 2 points along 2 orthogonal dimensions
 - Whether task is getting information or executing command
 - Whether it is effected manually or automatically

	manual	automatic
information	proximate selection & contextual information	automatic contextual reconfiguration
command	contextual commands	context-triggered actions

Sample Context-Aware Apps

ParcTabs



ParcTabs

Xerox PARC
Want, Schilit, et al

- Active badge + wireless
 - Rough location + ID
- Proximate selection
 - Interfaces for nearby objects
- Auto-diaries
 - People, places, and time
- Triggers
 - Alerts on preset events
- Reconfiguration
 - Bind device to room

Sample Context-Aware Apps

Active Badges



Active Badge

Olivetti / AT&T
Hopper, Harter, et al

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

Sample Context-Aware Apps

ParcTabs



ParcTabs

Xerox PARC
Want, Schilit, et al

- Active badge + wireless
 - Rough location + ID
- Proximate selection
 - Interfaces for nearby objects
- Auto-diaries
 - People, places, and time
- Triggers
 - Alerts on preset events
- Reconfiguration
 - Bind device to room



Proximate Selection

- User interface technique where located objects are emphasized or made easier to choose
- 3 kinds of located objects
 - Computer input and output devices requiring physical interaction
 - Printers, displays, thermostats, etc.
 - Non-physical objects and services
 - Bank accounts, menus, list of instructions, etc.
 - Set of places one wants to find out about
 - Restaurants, gas stations, stores, etc.
- Location information can be order alphabetically or by proximity or combinations
- Bandwidth requirements affect precision – coarse/fine grained

Sample Context-Aware Apps

ParcTabs

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

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

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

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

Sample Context-Aware Apps

ParcTabs



ParcTabs

Xerox PARC
Want, Schilit, et al

- Active badge + wireless
 - Rough location + ID
- Proximate selection
 - Interfaces for nearby objects
- Auto-diaries
 - People, places, and time
- Triggers
 - Alerts on preset events
- Reconfiguration
 - Bind device to room

Subject field

Filter field

Time	Subject	Filter	Other
10:32	[A]	[B]	[C]
10:38	[A]	[B]	[C]
10:39	[A]	[B]	[C]
10:41	[A]	[B]	[C]
10:44	[A]	[B]	511 22 518
10:46	[A]	[B]	[C]

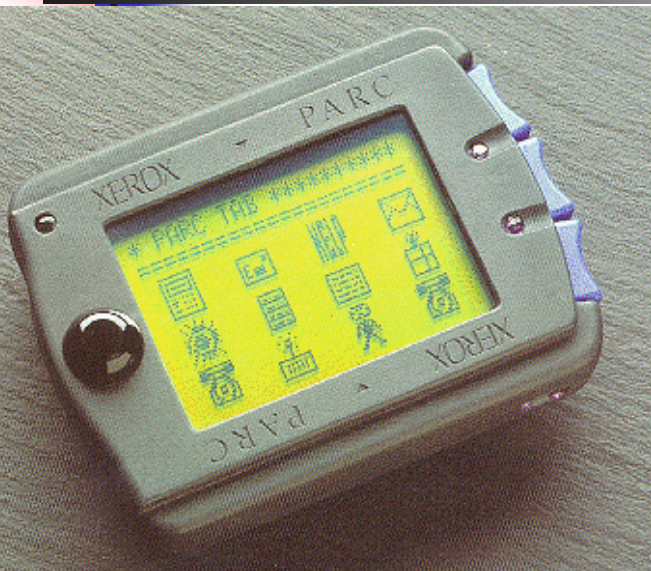
Title line

Biography

Mike's biography.

Sample Context-Aware Apps

ParcTabs



ParcTabs

Xerox PARC
Want, Schilit, et al

- Active badge + wireless
 - Rough location + ID
- Proximate selection
 - Interfaces for nearby objects
- Auto-diaries
 - People, places, and time
- Triggers
 - Alerts on preset events
- Reconfiguration
 - Bind device to room



Contextual Commands & Triggers

- Queries on contextual information produce different results according to context in which issued
- Location browser views location-based filesystem
 - Directories (named after locations) contain files, programs, links
 - Moving from room-to-room changes displayed directory
 - Location directories writable to add customizable information
- Context-triggered actions
 - Simple IF-THEN rules specify how context-aware system adapts
 - Active Badge based Watchdog
 - Monitor activity and execute Unix shell commands based on context
 - Tab based Contextual Reminders
 - Pop up message with fuller descriptions when different situations occur – user may edit, dismiss, or ignore reminder

Category	Example
Date and time	after April 15 between 10 and 12noon
Location	in room 35-2200
Co-location	with {User Adams} with {Type Display} having {Features Color}

- badge location event-type action

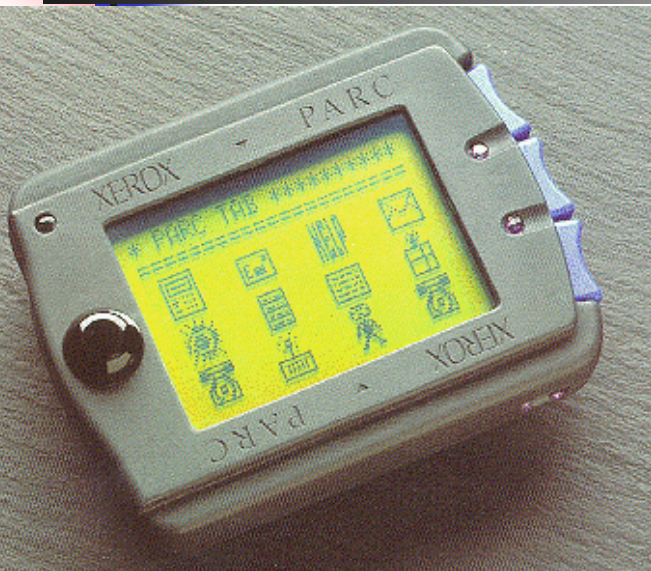
Coffee	Kitchen	arriving	"play -v 50 ~/sounds/rooster.au"
schilit	*	attention	"emacs -display \$NEARESTHOST:0.0"

"Like living in a rule-based expert system!"

- Watchdog configuration

Sample Context-Aware Apps

ParcTabs



ParcTabs

Xerox PARC
Want, Schilit, et al

- Active badge + wireless
 - Rough location + ID
- Proximate selection
 - Interfaces for nearby objects
- Auto-diaries
 - People, places, and time
- Triggers
 - Alerts on preset events
- Reconfiguration
 - Bind device to room



Contextual Reconfiguration

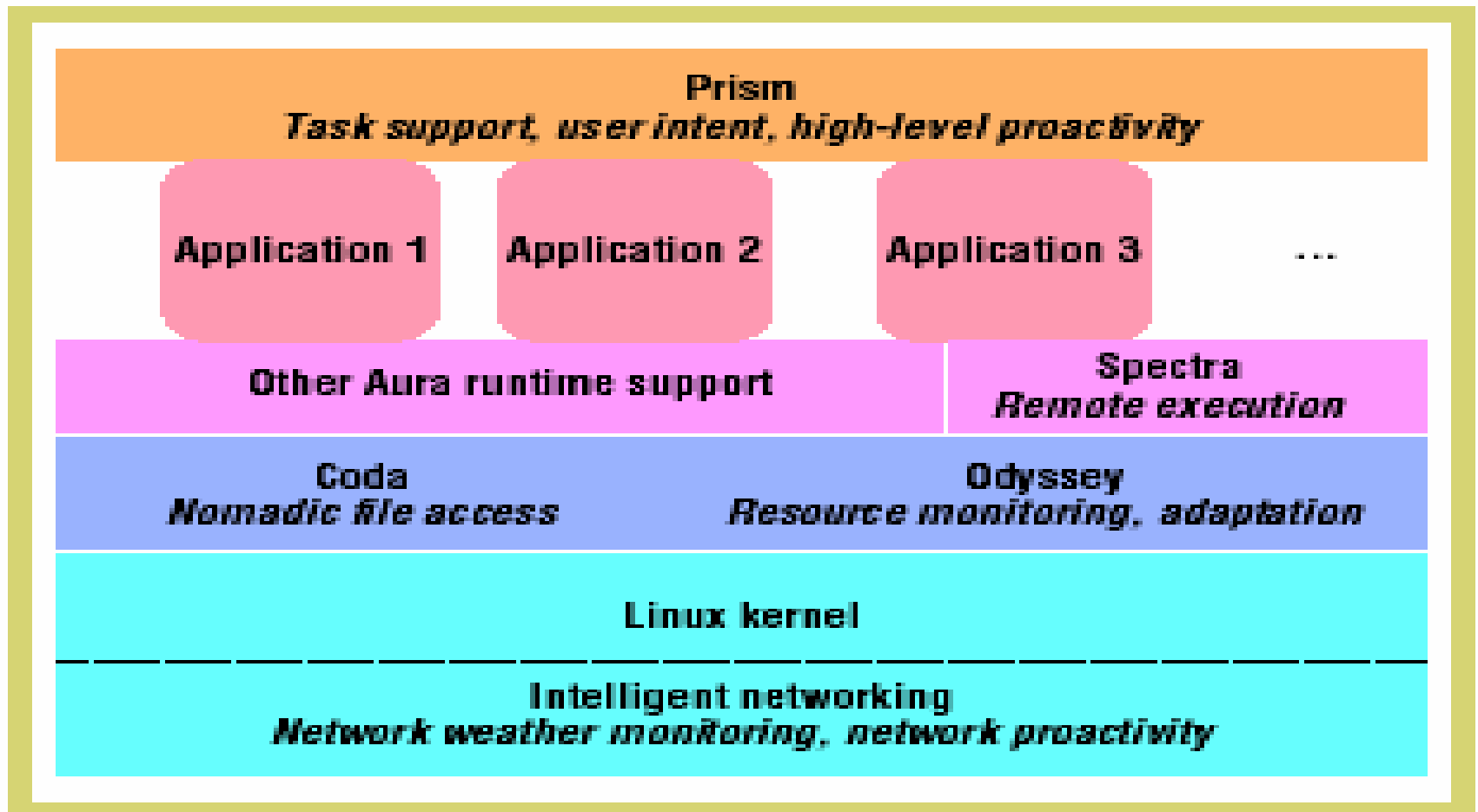
- Reconfiguration – add new components, remove existing components, alter connections between components
- Multi-user drawing program for PARCTab
 - Workspace (sort of whiteboard) for every room
 - Entering room causes automatic binding between mobile host and room's virtual whiteboard
 - Moving to different room brings up a different drawing surface
- Context of use defines system configuration and when hosts change location, configuration adapts
- Rapidly changing context – distracting to user and impractical to adapt to every change



Project Aura

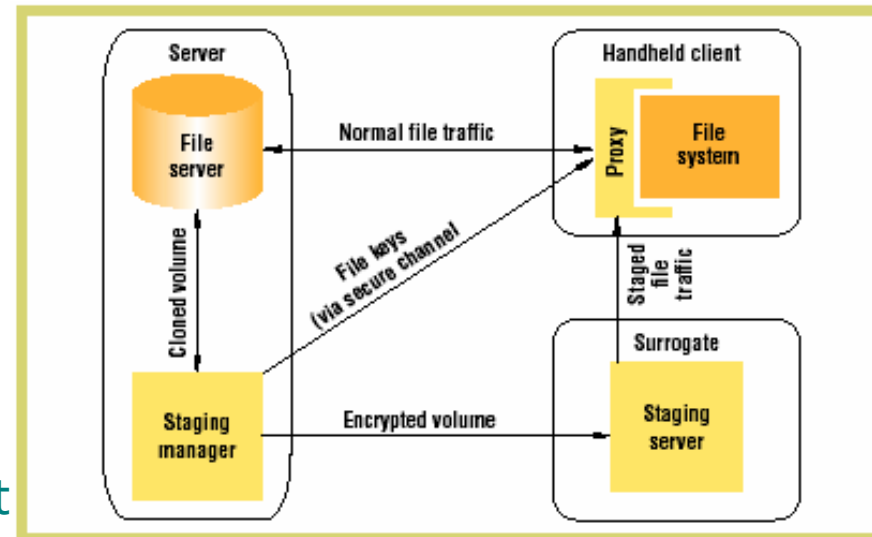
- Carnegie Mellon University – Garlan et al
- Human attention is the most precious resource in computer system
- Project Aura
 - Minimizes distractions on user attention by creating an environment that adapts to user's context and needs
 - Intended for pervasive computing environments involving wireless communication, handheld computers, smart spaces
 - Proactivity – system layer's ability to anticipate requests from a higher layer
 - Self-tuning – layers adapt by observing demands made on them and adjusting their performance and usage characteristics

Aura Architecture



Cyber Foraging

- Amplify capabilities of a resource-limited mobile client
- Compute/data-staging servers: surrogates of Aura client
- Data staging on surrogates
 - Reduce end-to-end Internet latency on file-intensive applications
 - Data staged in coarse-grained snapshots of file system data
 - Staging manager oversees snapshot creation
 - Caching trust rather than content using DES





Bandwidth Advisor & people Locator

- **Bandwidth Advisor**

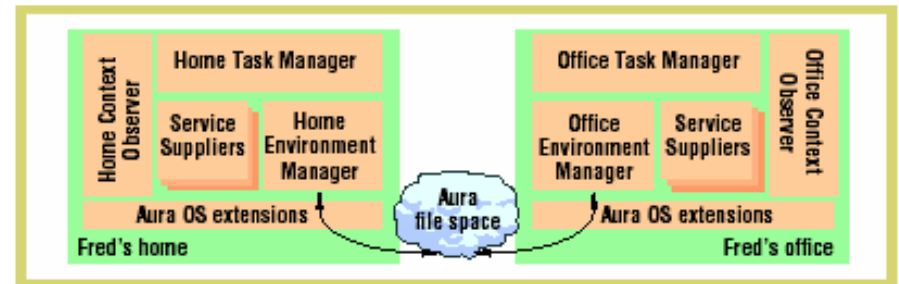
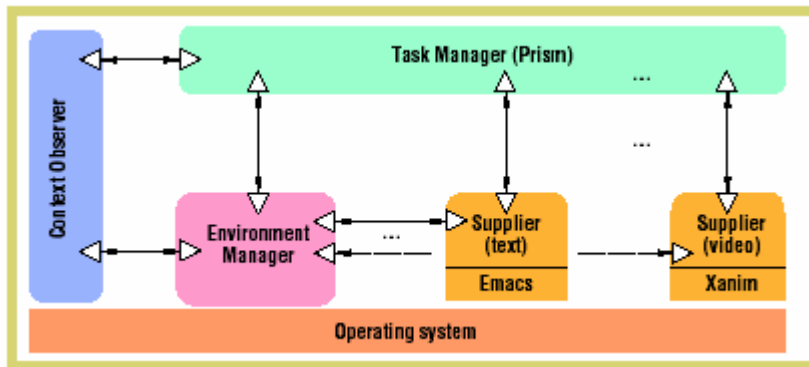
- 2 component categories – monitoring and prediction
- SNMP for monitoring, AP Segment Service for traffic and error rates, AP Device Service for cell population information
- Data stored on disk – prediction online or offline
- 3 models for predicting samples – PPREV (future same as recent), AV (average value), Arfima (auto-regressive fractionally integrated moving average)

- **People Locator**

- Based on signal strength and access point information
- 2 algorithms – pattern-matching (CMU-PM) and triangulation-based remapped interpolated algorithm (CMU-TMI)

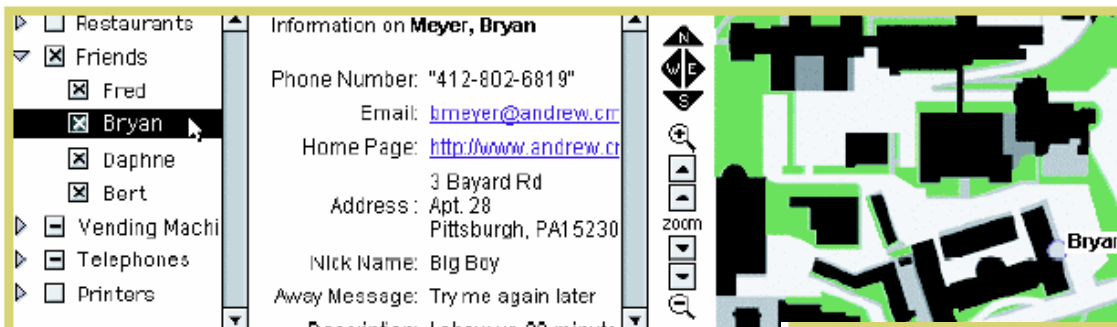
Capturing User Intent

- Task Manager, Context Observer, Environment Manager, Service Suppliers
- Interactions in Prism built on top of RPC or Corba
- Task mobility in Aura



PHD & Idealink

- Portable Help Desk – built on spatial and temporal awareness, determines user location – visual/audio
- Idealink – virtual planned/ad hoc collaboration environment, integrated with PHD for user preferences and schedules





Thanks !!!
