Context-Aware Computing 1 Overview

Mobile Computing

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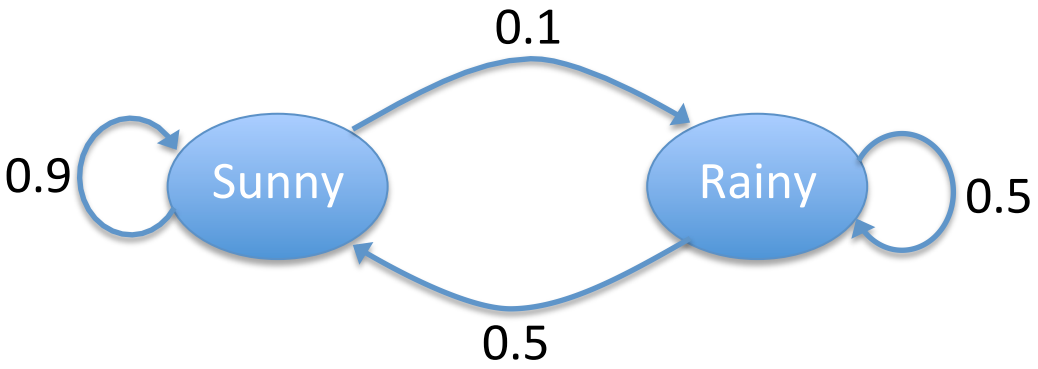
Markov Chain

- Random variable *x(t)* changes over time with discrete time *t=1, 2, 3, …*
  - *x(1), x(2), x(3), …, x(t), …*
- Each *x(t)* takes a value in state space $Q = \{s_1, s_2, \ldots, s_n\}$
- Transition probability
  - Probability of observing s_j when the previous value was s_i,
  - $P_{ij} = P(x(t+1) = S_j \mid x(t) = S_i)$

Transition Matrix

- State Transition Diagram
- Transition Matrix

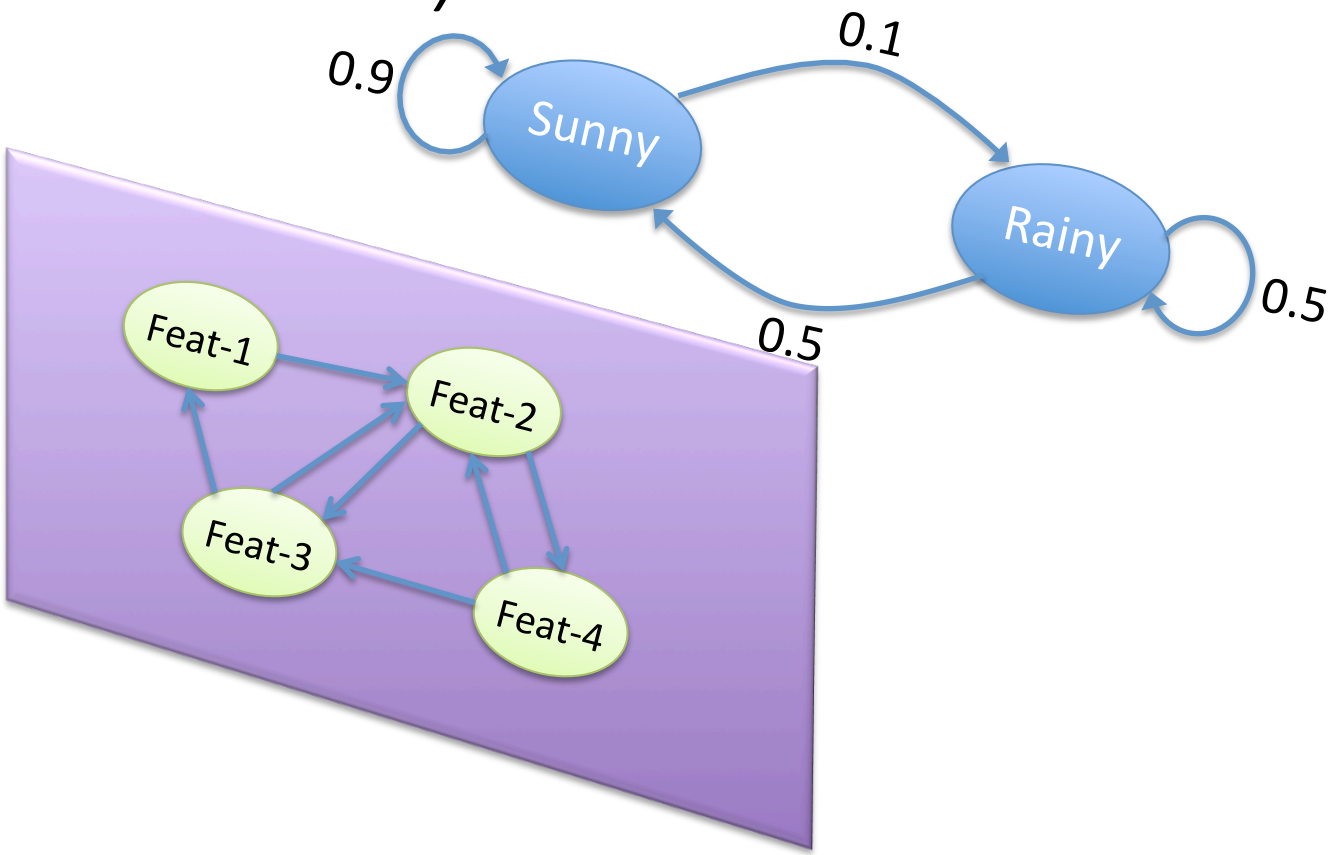


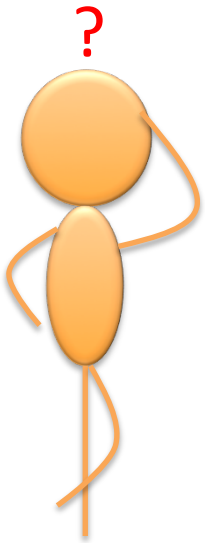
	(Sunny)	(Rainy)
(Sunny)	0.9	0.1
(Rainy)	0.5	0.5

Quiz

- Provide a state transition diagram and transition probability matrix for the following Markov Process
  - State Space: {sunny, rainy}
  - If sunny today, then sunny tomorrow with 90%
  - If sunny today, then rain tomorrow with 10%
  - If rain today, then either sunny or rain with 50%

We can't see the state
(following a Markov Process)

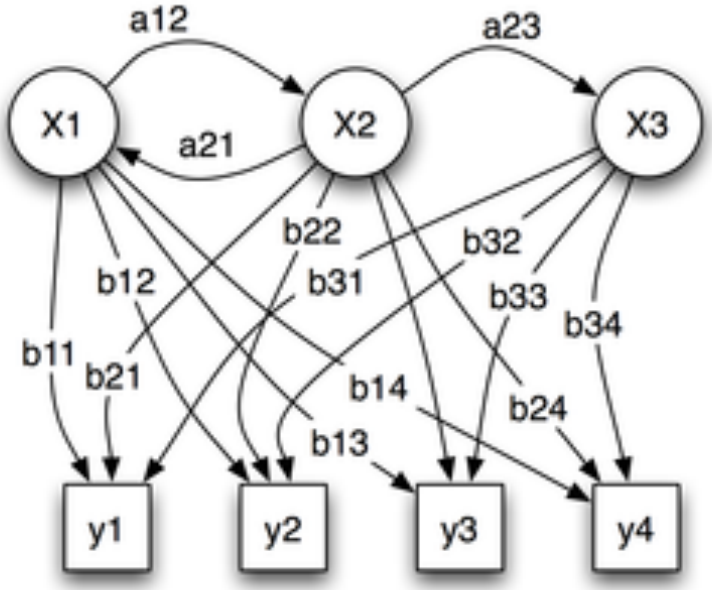




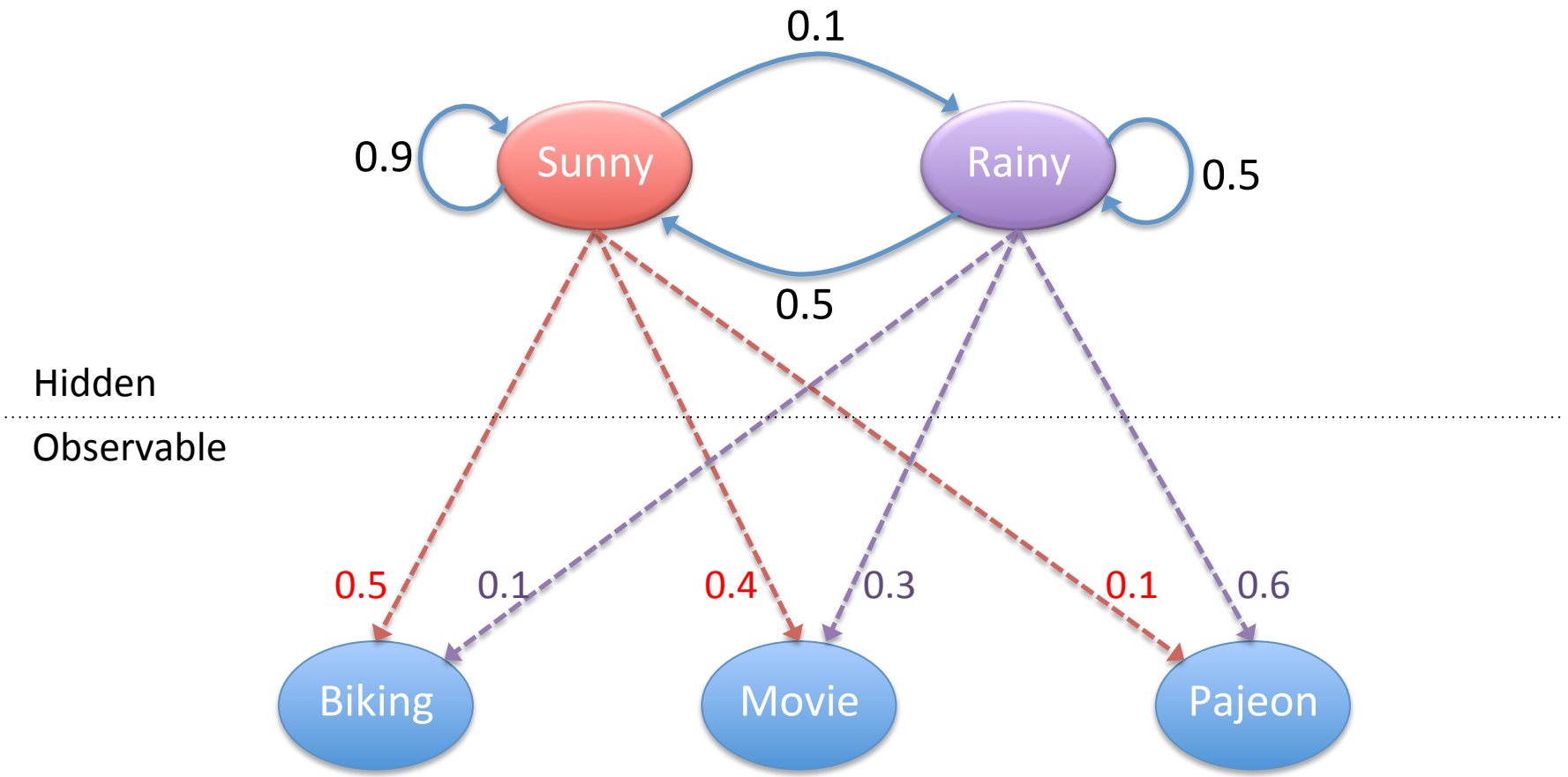
We only observe consequences of state
Then we infer the state behind the scene

Hidden Markov Model

- Hidden states X_1, X_2, … X_n of a Markov Chain with transition probability a_{ij}
- Observed states y_1, y_2, …, y_n
- Output probability $\{b_{ij}\}$
- From observed states, infer the hidden states and their transition probabilities



Hidden Markov Model for Weather



Quiz

- Draw the Hidden Markov Model for the following:
- Alice wants to reckon the weather (sunny or rainy) by observing Bob's activity (biking, movie, pajeon)
- Markov Chain of the weather is given as ….
- Output probability is given as
  - b(sunny,biking) = 0.5
  - b(sunny,movie) = 0.4
  - b(sunny,pajeon) = 0.1
  - b(rainy,biking) = 0.1
  - b(rainy,movie) = 0.3
  - b(rainy,pajeon) = 0.6

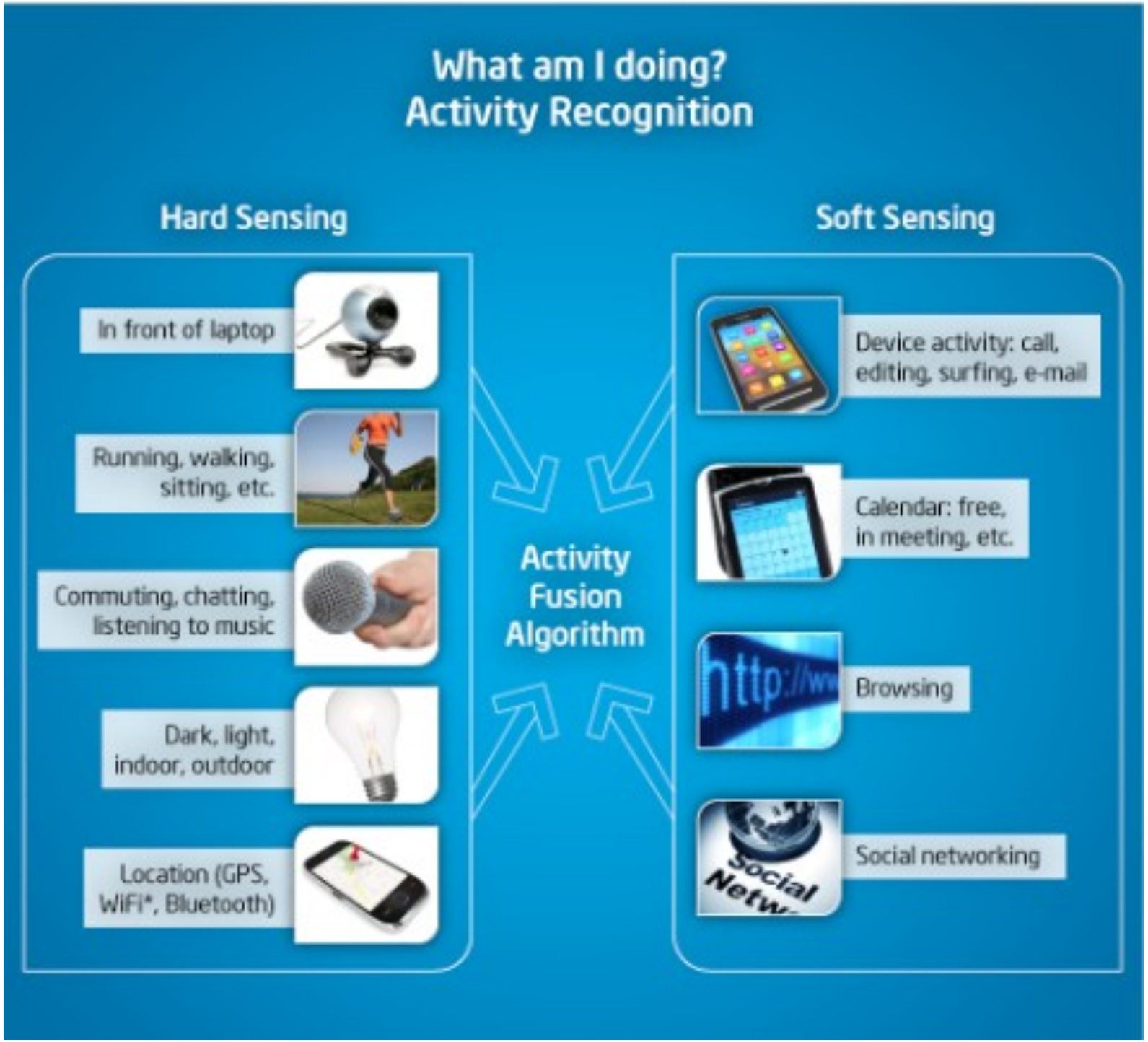

CONTEXT-AWARE
COMPUTING
How Am I
Feeling?
Who Am
I With?
Why Am
I Here?
What Am
I Doing?
Where Am
I Going?
When Do
I Need
To Leave?

Context

- Original meaning
  - the interpretation of text changes by the context
  - In what setting is the text/words being told?
  - “I am dying”
- Definition in American Heritage Dictionary
  - The circumstances that form the setting for an event, statement, or idea,
  - and in terms of which it can be fully understood and assessed

Definitions

- Dey
  - Context is any information that can be used to characterize the situation of an entity.
  - An entity is a person, place, or object that is considered relevant to the interaction
  - between a user and an application, including the user and applications themselves
- Schmidt
  - “knowledge about the user’s and IT device’s state, including surroundings, situation, and to a less extent, location


What am I doing?
Activity Recognition
Hard Sensing
In front of laptop
Running, walking, sitting, etc.
Commuting, chatting, listening to music
Dark, light, indoor, outdoor
Location (GPS, WiFi*, Bluetooth)
Activity Fusion Algorithm
Soft Sensing
Device activity: call, editing, surfing, e-mail
Calendar: free, in meeting, etc.
Browsing
Social networking

Context Source: Sensors

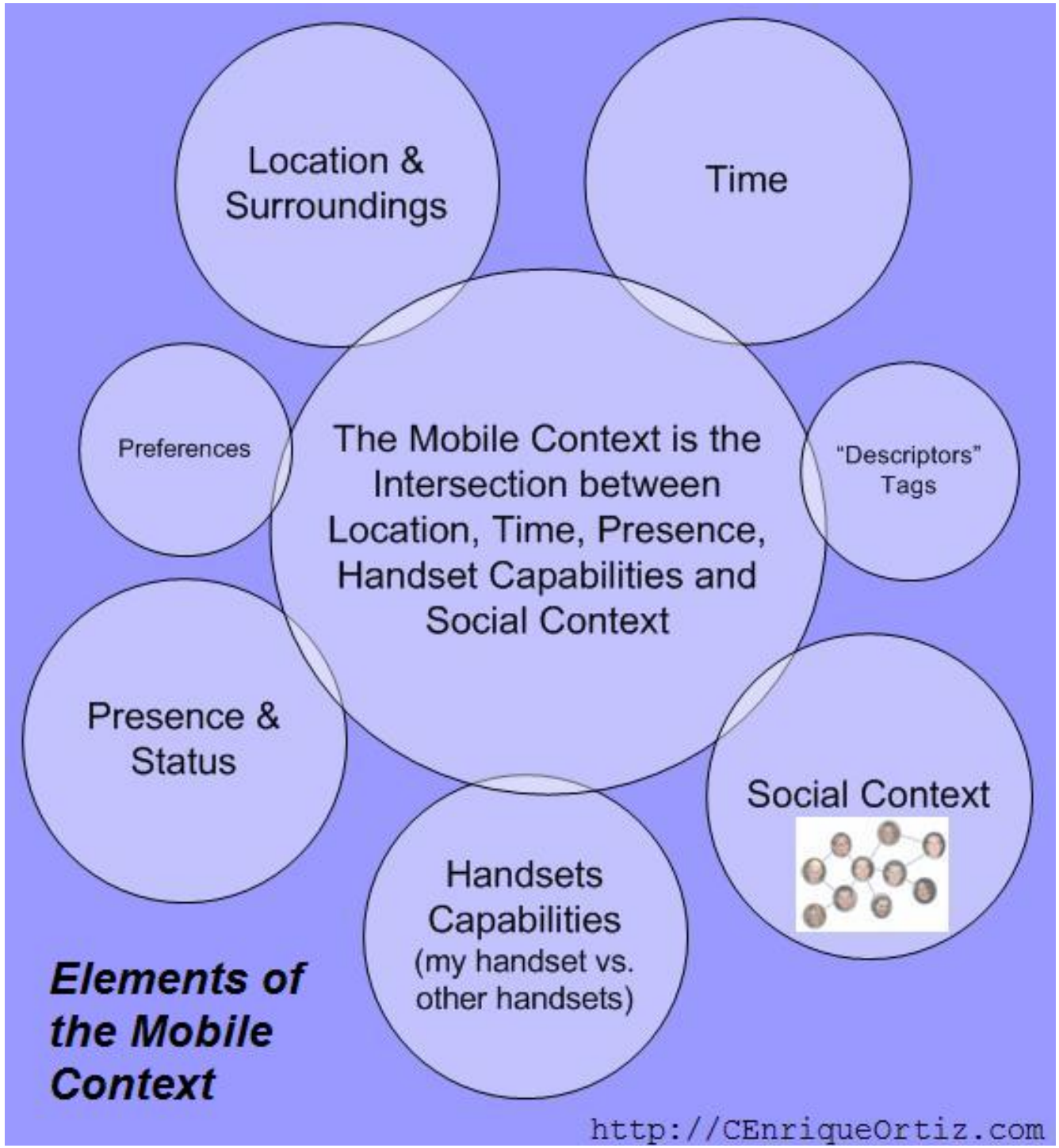
- Hard sensor
  - Real, Hardware Sensors
  - Location: GPS, Cell tower (Google), WiFi (Skyhook)
  - Motion: accelerometer
  - Proximity, Light, Audio, Video
- Soft sensor
  - Virtual, Software Sensors
  - Explicit: schedule, todo list, contacts
  - Implicit : web browsing, email, chat, app usage, resource usage, …

Context Awareness

- Computers can both sense, and react based on their environment.
- Context aware systems are concerned with
  - acquisition of context (e.g. using sensors to perceive a situation),
  - abstraction and understanding of context (e.g. matching a perceived sensory stimulus to a context),
  - application behavior based on the recognized context (e.g. triggering actions based on context).

Context types

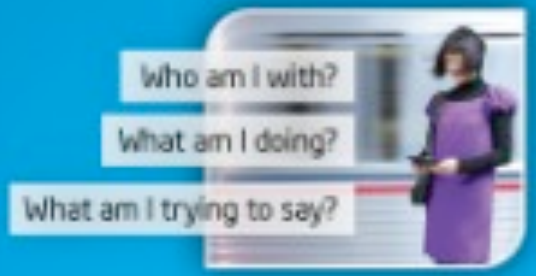
- Computing context
  - Network connectivity, communication costs, and communication bandwidth, and nearby resources such as printers, displays, and workstations.
- User context
  - User's profile, location, people nearby, social situation.
- Physical context
  - Lighting, noise levels, traffic conditions, and temperature.
- Time context
  - time of a day, week, month, and season of the year.
- Context history


Location & Surroundings
Time
Preferences
The Mobile Context is the Intersection between Location, Time, Presence, Handset Capabilities and Social Context
"Descriptors" Tags
Presence & Status
Social Context
Handsets Capabilities
(my handset vs. other handsets)
Elements of the Mobile Context
http://CEnriqueOrtiz.com

Device Context → Personal Context → Crowd Context

Flip UI based on accelerometer

Disable keys when close to ear



Continuously capture the person's context

Analyze and recommend

Capture personal context

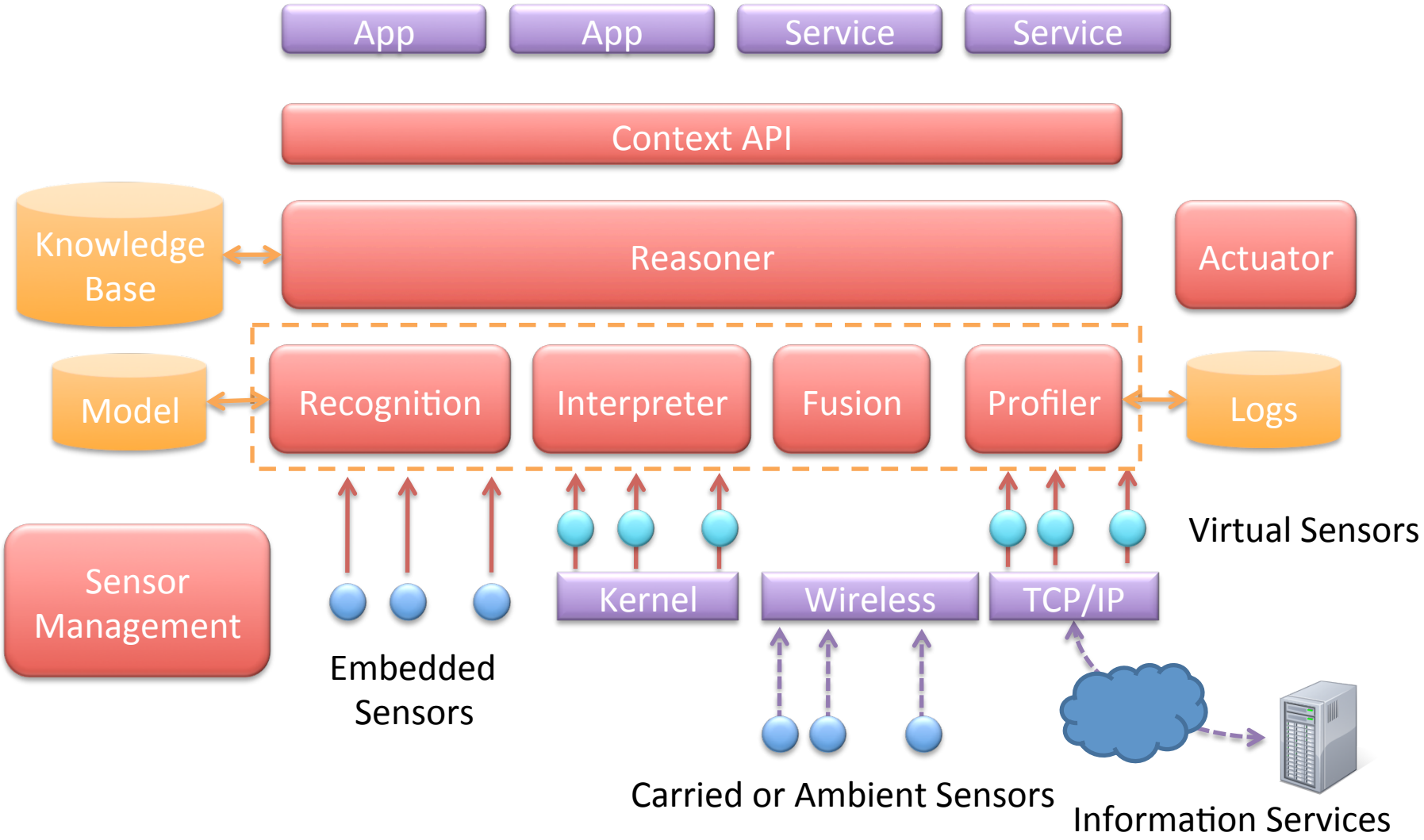
Aggregate across crowds

Analyze and recommend

Combination of Context

- Combining several context values may generate a more powerful understanding of the current situation.
  - Knowing the current location and current time, together with the user's calendar, the application will have a pretty good idea of the user's current social situation, such as having a meeting, sitting in the class, waiting in the airport, and so on.

System Architecture for Context-Aware Computing



Museum Guide

- Explain each art work when the user approaches it
- Tailored for user's interest, age, job,…
- Provide event / sale information near the user
- …

- Ex
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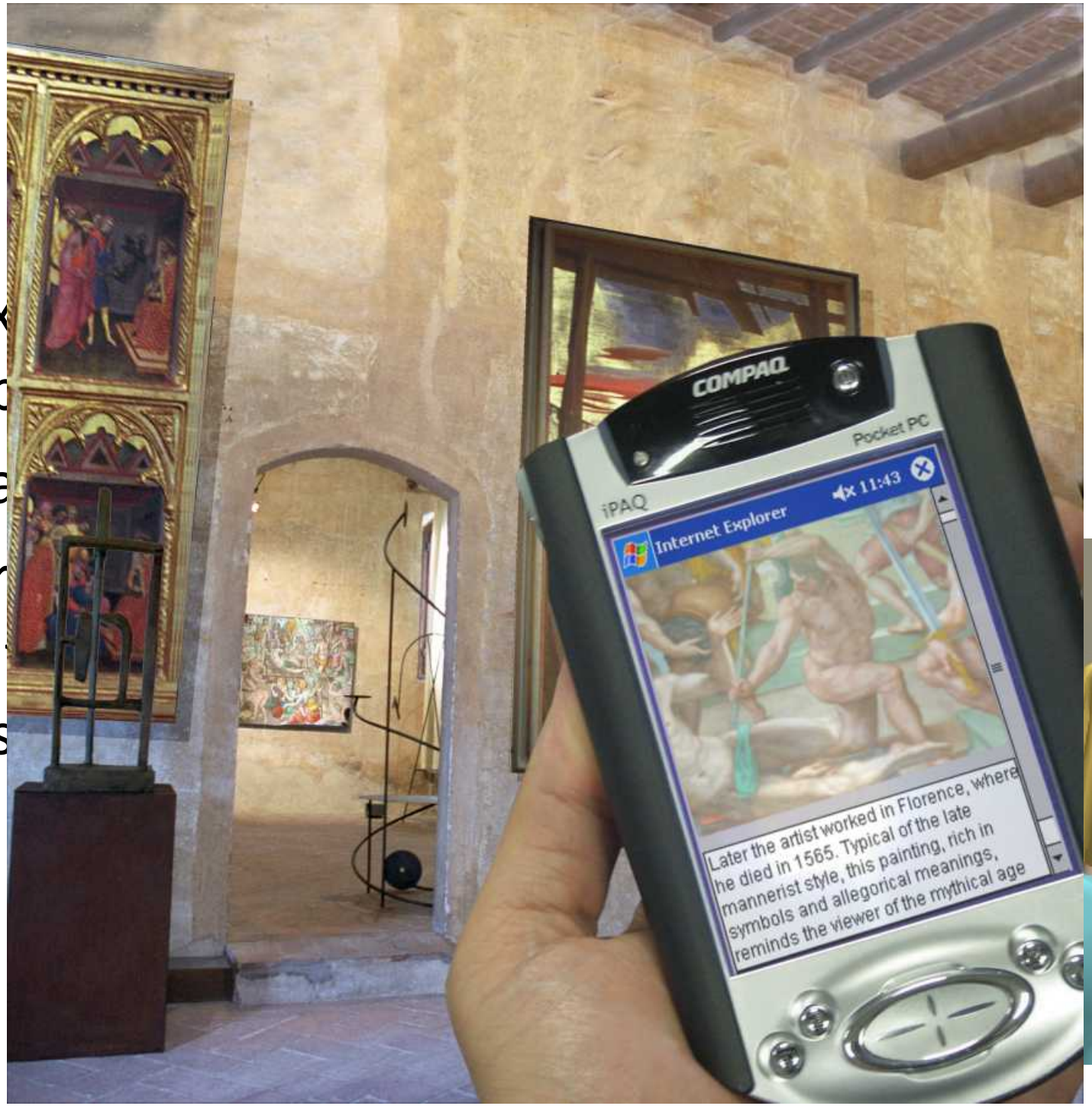
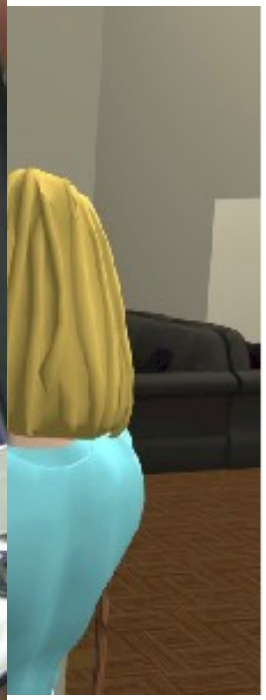
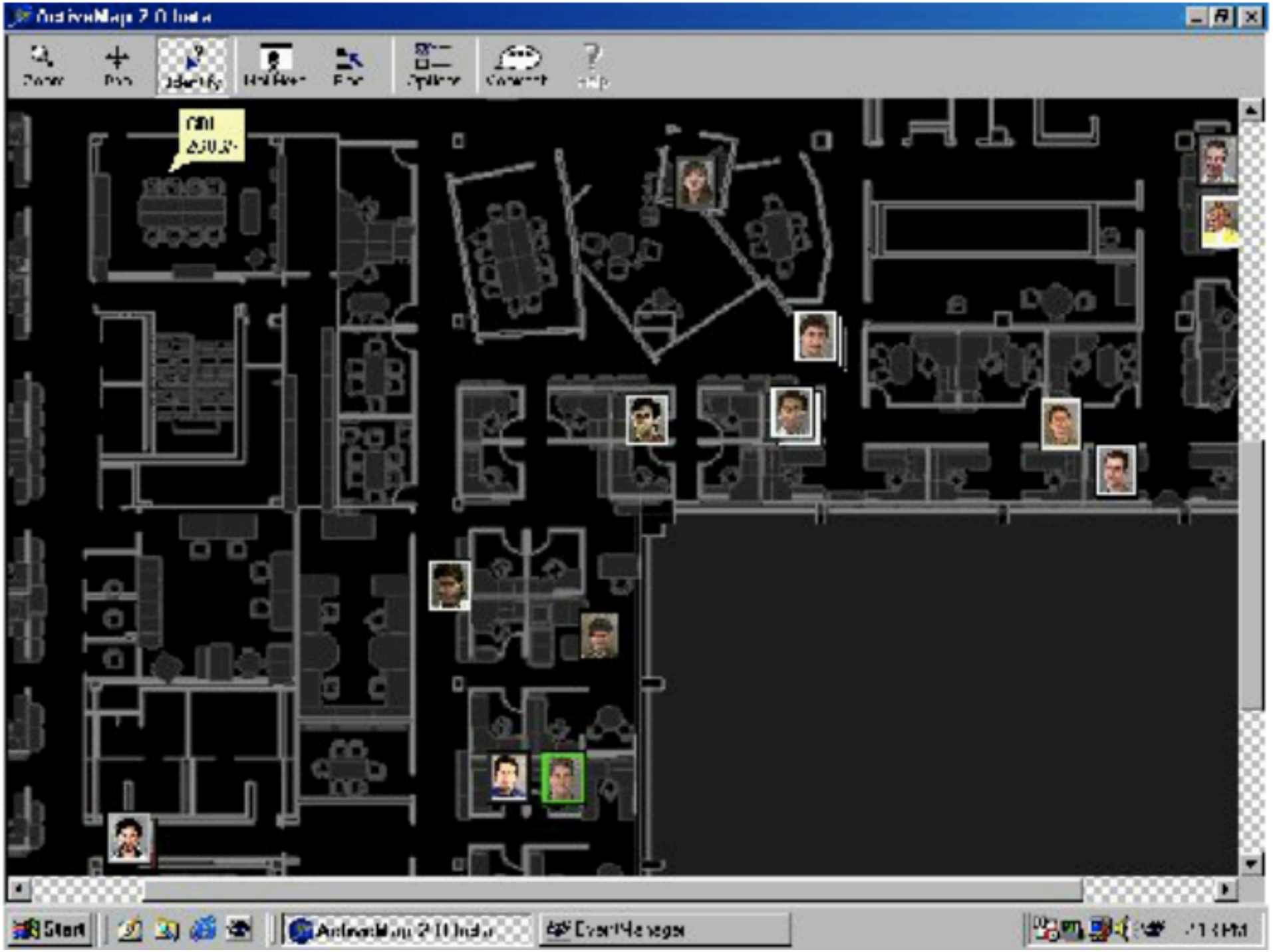
- Ta
- Pr
  in
  us
- …





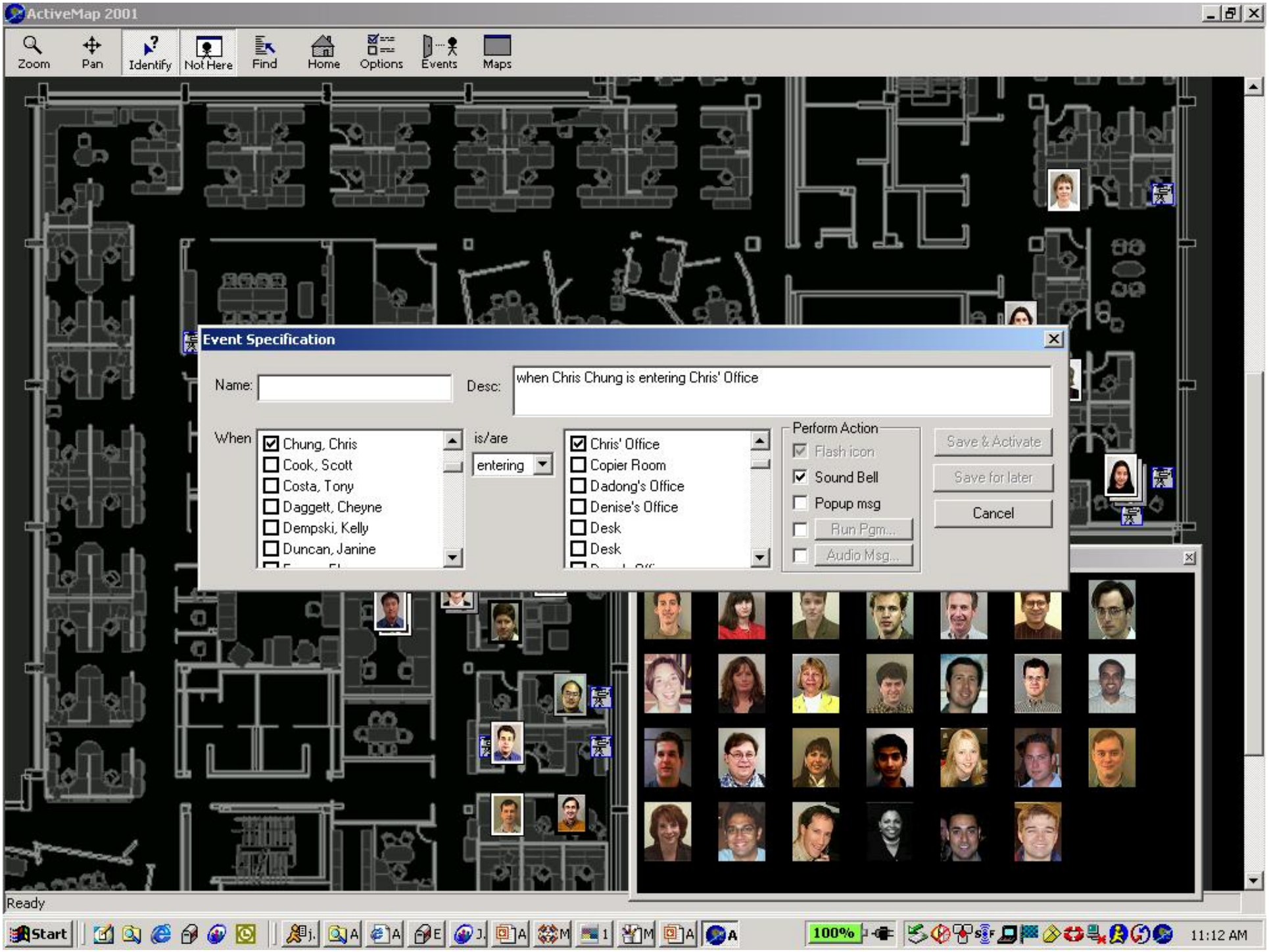
Active Map

- by Xerox Parc
- The location information (room number) is collected and the individual faces are shown at the locations of people on the map, which is updated every few seconds



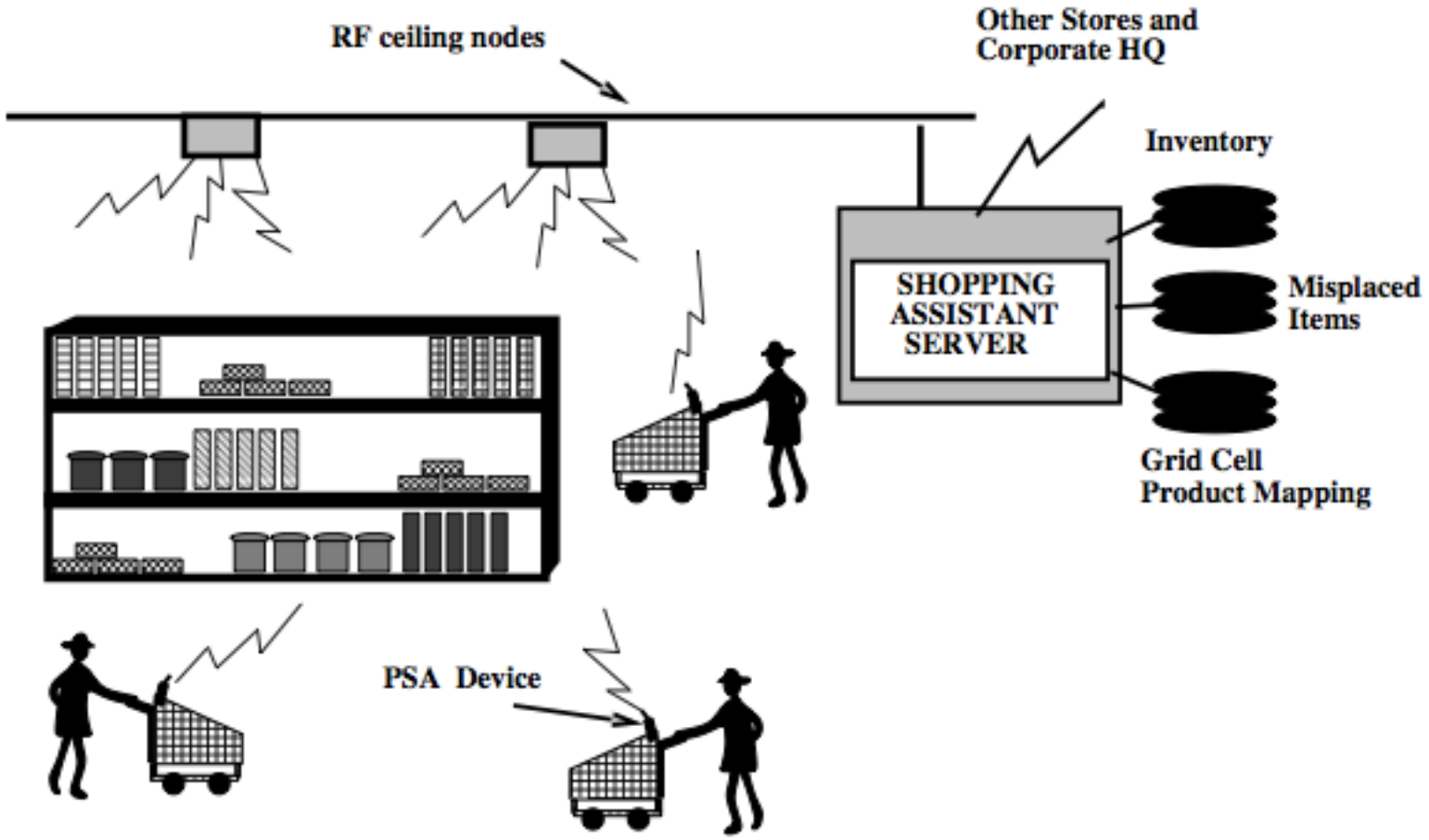
Active Map

- by Xerox Parc
- The location information (room number) is collected and the individual faces are shown at the locations of people on the map, which is updated every few seconds
- Notify when interested events occur regarding people's locations


ActiveMap 2001
Zoom
Pan
Identify
Not Here
Find
Home
Options
Events
Maps
Event Specification
Name:
Desc:
when Chris Chung is entering Chris' Office
When
Chung, Chris
Cook, Scott
Costa, Tony
Daggett, Cheyne
Dempski, Kelly
Duncan, Janine
is/are
entering
Chris' Office
Copier Room
Dadong's Office
Denise's Office
Desk
Desk
Perform Action
Flash icon
Sound Bell
Popup msg
Run Pgm...
Audio Msg...
Save & Activate
Save for later
Cancel
Ready
Start
100%
11:12 AM

Shopping Assistant

- by AT&T Bell Lab
- Guide the shoppers through the store
  - Provide details of items, help locate items, point out items on sale, do a comparative price analysis, and so forth.
- Customers are divided into two classes:
  - regular customers who shop anonymously without profiles in store,
  - customers who signed up with a store and will get additional discounts in exchange for sacrificing their privacy.


RF ceiling nodes
Other Stores and
Corporate HQ
Inventory
SHOPPING
ASSISTANT
SERVER
Misplaced
Items
Grid Cell
Product Mapping
PSA Device

Indoor Positioning

Cyberguide

- by Georgia Tech
- Provide information services to a tourist about
  - current location;
  - find directions,
  - retrieve background information, and leave comments on the interactive map.
  - The travel diary is automatically compiled
  - make suggestions on places of interest to visit.


hands-free
earphone &
microphone
portable
computer
cellular
telephone
GPS
receiver

Adaptive Phone

- adapt to the font size to the users activity (a large font when the user is walking, small font when stationary) as well as to environmental conditions (e.g., light level).
- the profiles of the mobile phone are selected automatically based on the recognized context.
  - The phone chooses to ring, vibrate, adjust the ring volume, or keep silent, depending on whether the phone is in hand, on a table, in a suitcase, or outside.

Challenges

- Context acquisition
- Context refinement
- Profiling
- Context modeling (representation)
- Context reasoning
- Context imperfectness

Challenges

- Context acquisition
  - Given a set of contexts, provide appropriate and best low-data
  - Identify, find, and obtain context data from various context source
- Context refinement
- Profiling
- Context modeling (representation)
- Context reasoning
- Context imperfectness

Challenges

- Context acquisition
- Context refinement
  - Convert sensor-data into mid-level context
  - Movement → activity type
  - Sound → activity or surrounding situation
  - Image → place/ situation
- Profiling
- Context modeling (representation)
- Context reasoning
- Context imperfectness

Challenges

- Context acquisition
- Context refinement
- Profiling
  - Derive personalized context pattern based on history data
  - Movement profiling for significant-place learning, location prediction
  - Behavior profiling for behavior prediction/recommendation
  - Social profiling for social-activity prediction, relationship learning
  - Preference profiling
- Context modeling (representation)
- Context reasoning
- Context imperfectness

Challenges

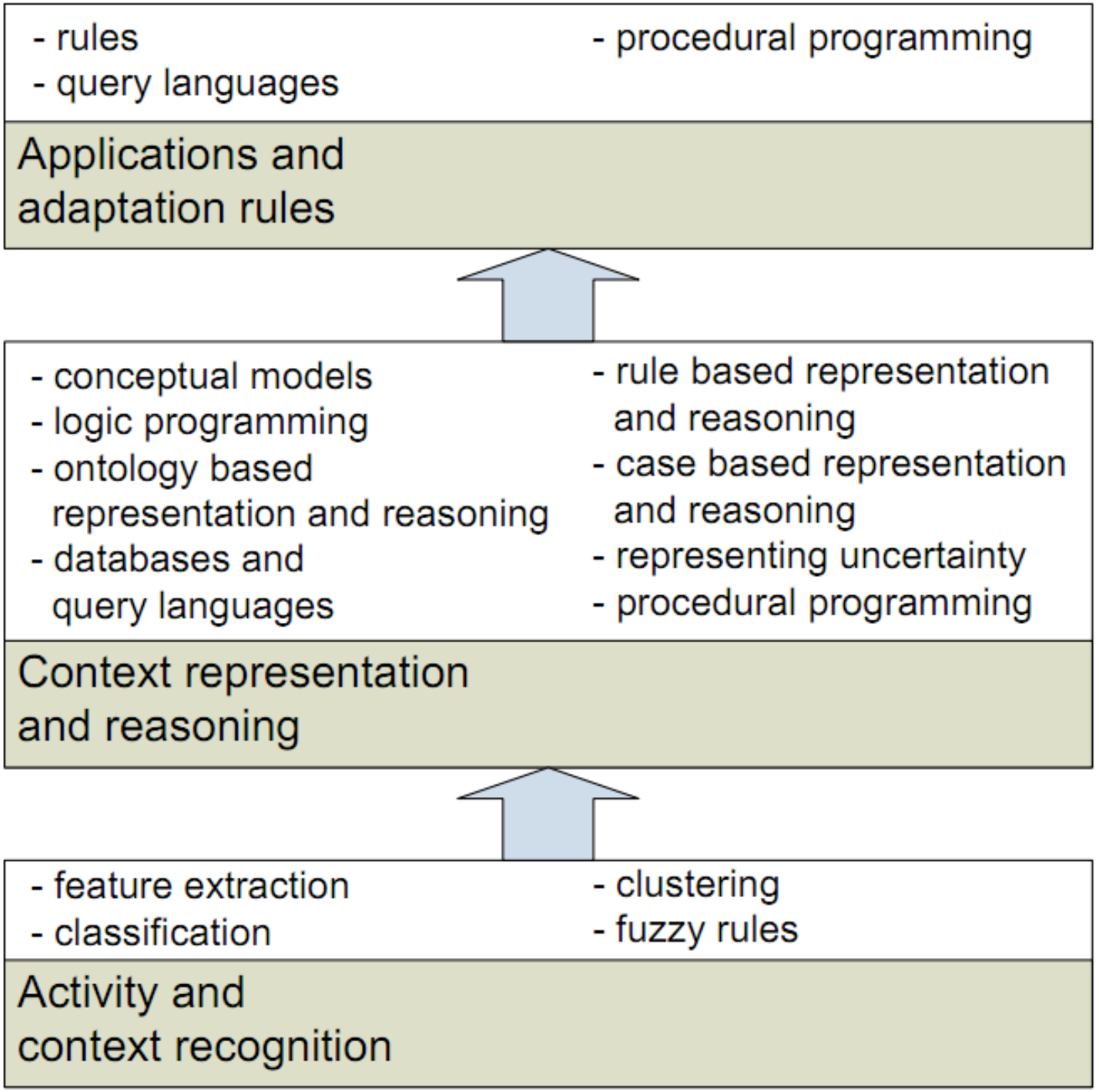
- Context acquisition
- Context refinement
- Profiling
- Context modeling (representation)
  - Ontology (no uncertainty, heavy)
  - Bayesian networks
  - Fuzzy logic
  - Probabilistic Relational Model
  - SCM (Symbol string Clustering Map)
- Context reasoning
- Context imperfectness

Challenges

- Context acquisition
- Context refinement
- Profiling
- Context modeling (representation)
- Context reasoning
  - Description Logic (deterministic, deductive)
  - Machine Learning (probabilistic, inductive)
- Context imperfectness

Challenges

- Context acquisition
- Context refinement
- Profiling
- Context modeling (representation)
- Context reasoning
- Context imperfectness
  - Integration of Bayesian network with ontology
  - Fuzzy /PRM/ Markov Logic


- rules
- query languages
- procedural programming
Applications and adaptation rules
- conceptual models
- logic programming
- ontology based representation and reasoning
- databases and query languages
- rule based representation and reasoning
- case based representation and reasoning
- representing uncertainty
- procedural programming
Context representation and reasoning
- feature extraction
- classification
- clustering
- fuzzy rules
Activity and context recognition