
Context Aware Framework

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Outline

- Definition of Context
 - Context Awareness
 - Examples of Context Aware Applications
 - Survey on existing Context Aware Projects
 - Situation & Context
 - From sensor to context and activity
 - Context Modeling
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 - C-DAC's Context Aware Framework
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Definition of Context

- Schilit and Theimer (1994) refer to context as location, identities of nearby people and objects, and changes to those objects.
- In a similar definition, Brown, Bovey et al. (1997) define context as location, identities of the people around the user, the time of day, season, temperature, etc.
- Ryan, Pascoe et al. (1998) define context as the user's location, environment, identity and time.
- Dey and Abowd's definition (2001)
 - 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.

Context Awareness

- Hull, Neaves et al. (1997) and Pascoe, Ryan et al. (1998) define context-aware computing to be the ability of computing devices to detect and sense, interpret and respond to aspects of a user's local environment and the computing devices themselves.
 - Schilit, Adams et al. (1994), Brown, Bovey et al. (1997), Davies, Mitchell et al.(1998) define context-aware applications to be applications that dynamically change or adapt their behavior based on the context of the application and the user.
 - Dey and Abowd's definition (2001)
 - A system is context-aware if it uses context to provide relevant information and / or services to the user, where relevancy depends on the user's task.
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Context information

- Almost any information available at the time of an interaction can be seen as context information.
 - Some examples are:
 - identity
 - spatial information
 - e.g. location, orientation, speed, and acceleration
 - temporal information
 - e.g. time of the day, date, and season of the year
 - environmental information
 - e.g. temperature, air quality, and light or noise level
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Context information (Contd...)

- social situation
 - e.g. who you are with, and people nearby

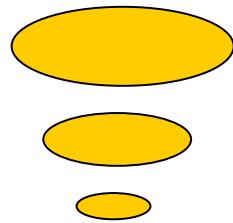
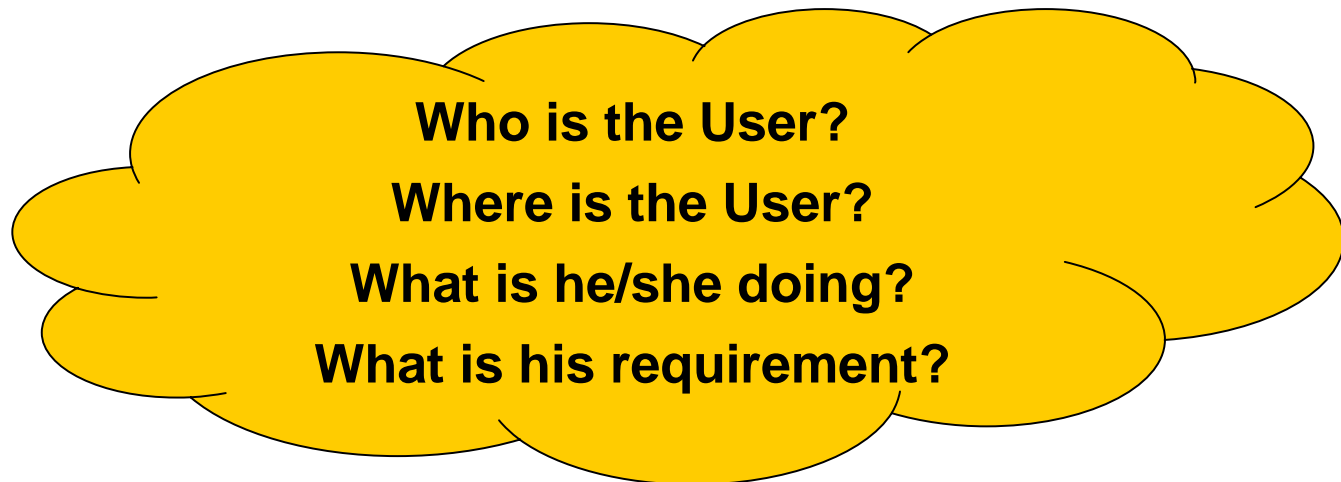
 - resources that are nearby
 - e.g. accessible devices, and hosts

 - availability of resources
 - e.g. battery, display, network, and bandwidth

 - physiological measurements
 - e.g. blood pressure, heart rate, respiration rate, muscle activity, and tone of voice

 - activity
 - e.g. talking, reading, walking, and running
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Context Aware Applications



Types of context-aware applications

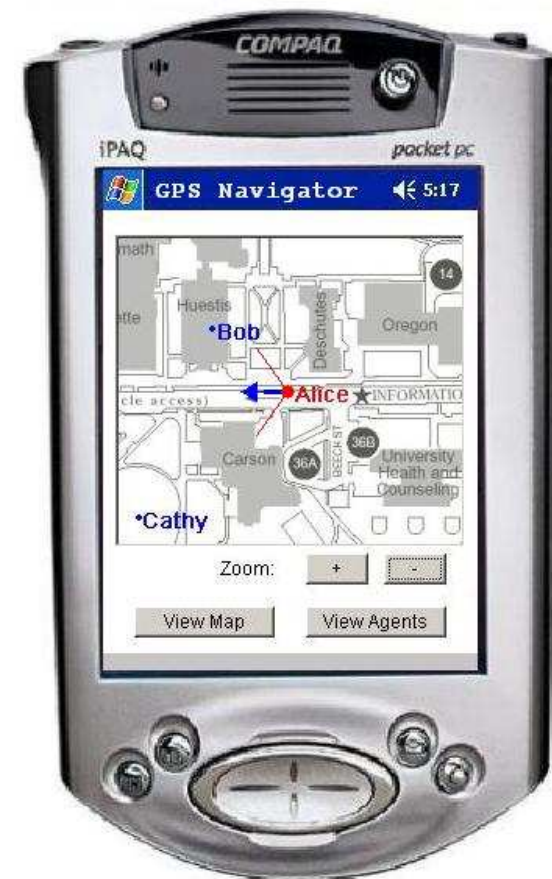
- Automatically execute a service
 - e.g. Smart homes: turn off lights, adjust temperature, sending alerts and reminders

 - Present the information and services to a user
 - e.g. Tour guide, Active Badges

 - Tag the context to the information for later retrieval
 - e.g. Digital camera meta-data: time, location
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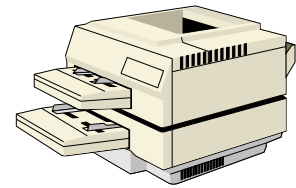
Example: Navigator Application

- Suppose we want to build a navigation aid that will give a person's location and give directions to some destination.
- Contexts that we need:
 - Location
- So, we need to build an application that will be able to read context from a location sensor, such as a GPS device.

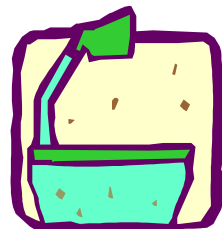
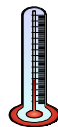


Example application: what's near to me?

Find this for me (Resource Discovery)



*“Print map on a color printer,”
and system sends data to nearest
available free color printer and tells
you how to get there*



Example: Adaptive GSM phone/PDA

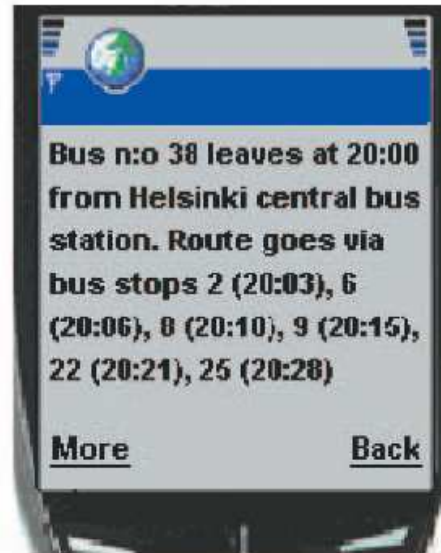
- PDA: notepad application changes its characteristics depending on user activity
 - Large font when walking, small font when stationary
 - Change the intensity level depending on the lighting conditions

 - Phone: decide ring volume or vibration depending on situation
 - In hand, in a suitcase, on a table, in a classroom/conference?

 - Context:
 - User's activity, intensity of light, pressure and proximity of other people.
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Example: Adaptive GSM phone/PDA

- More efficient UI as context changes
 - Brighter display in dark place
 - Simplified text when I am moving



normal



dark place &
user is moving

Survey on Context Aware Applications

- The Active Badge system-- the Olivetti Research Lab at the beginning of the 90's
 - Parc Tab– Xerox Palo Alto Research Centre
 - In/Out board-- Georgia Institute of Technology (GeorgiaTech)
 - DUMMBO (Dynamic Ubiquitous mobile meeting board)-- Georgia Institute of Technology (GeorgiaTech)
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Survey on Context Aware Applications

- Cyber guide project– Georgia Tech. in the mid 90's.
 - GUIDE-- At the University of Lancaster between 1996 and 1999.
 - Forget-Me-Not-- Rank Xerox Research Center at the beginning of the 90's
 - StartleCam– At MIT media Lab
 - Aware-home-- Georgia Institute of Technology's Future Computing Environments Group (FCE)
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Situation & Context

From sensor to context and activity

How to describe a Situation?

- It is difficult to describe and detect a situation
 - A car is going to have a serious accident
 - Two people are undecided what to buy
 - Someone is sleeping in a room
 - A family having dinner

...but often it is a prerequisite to recognize situations for building intelligent objects

How is a situation characterized using

sensor value?

- Example: Someone is sleeping in a room

 - Sensors
 - Motion sensor overseeing the room (ON/OFF)
 - Weight sensor in each leg of the bed (0 - 100)
 - Light sensor (0 - 100)
 - Door sensor (OPEN/CLOSE)
 - Pressure mat in a rug on the floor (ON/OFF)
 - Microphone providing noise level (0 - 100)

 - Find a function that takes sensor values as input and that tells if someone is sleeping in the room or not
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Modeling the Domain

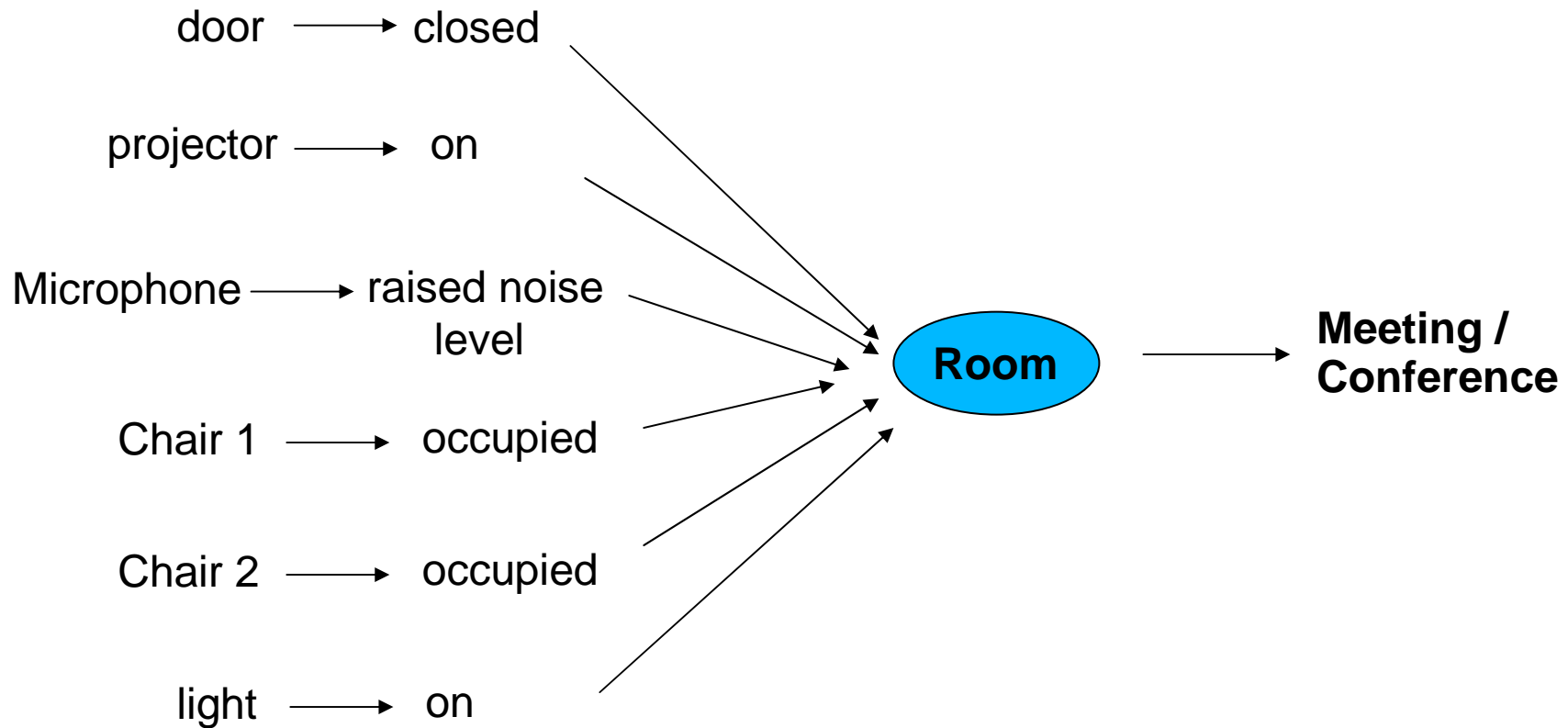
- Alternative approaches
 - Top down
 - Situation -> Context -> Features -> Sensors
 - Bottom up
 - Sensors -> Features -> Context -> Situation

 - Do not try to model the world.....model your application's world!
 - Dr. Albrecht Schmidt
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Bottom-up Context Example

- sofa
 - free
 - occupied with one person
 - occupied with two people
 - occupied with three people
 - door
 - open
 - closed
 - degree of openness
 - interaction
 - briefcase
 - empty
 - loaded
 - open
 - closed
 - interaction
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Higher Level Context - Example



Context Modeling

Context Modeling

- Various Modeling Approaches
 - Key-Value Model
 - Markup Scheme Model
 - Graphical Model
 - Object Oriented Model
 - Logic Based Model
 - Ontology based Model
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Different architecture using different context model: courtesy 'A survey on context-aware system' by Matthias Baldauf and Schahram Dustdar and Florian Rosenberg

Architecture	Sensing	Context module	Context model & processing
CASS	Centralized middleware	Sensor nodes	Relational data model
CoBra	Agent based	Context acquisition module	Ontologies (OWL)
Context Management framework	Blackboard based	Resource server	Ontologies (RDF)
Context toolkit	Widget based	Context widgets	Attribute-value tuples
CORTEX	Sentient object model	Context component framework	Relational data model
Gaia	MVC (extended)	Context providers	4-ary predicates (DAML+OIL)
Hydogen	Three layered architecture	Adapter for various context types	Object-oriented
SOCAM	Distributed with centralized server	Context providers	Ontologies (OWL)

Approaches for building intelligence

Rule based approach

- A (fixed) set of rules that specify a context
 - Explicit definition of context parameters (features) to match a context
 - In many application scenarios this is very simple to implement
 - It is easy for small number of features and contexts that are well understood

 - Example mobile phone
 - `in_hand := (touch==TRUE) && (acceleration > EPSILON)`
 - `in_suitcase := (touch==FALSE) && (light == DARK)`
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Off line learning (Supervised training)

- The context is learned by “experience”
- Data examples for a context is learned base on sensor data or feature
- The training data is collected in typical situations that belong to a context
- In a new situation the received stimulus (sensor data / features) are compared to the data learned
- Different algorithms, e.g.
 - Statistics
 - Nearest Neighbour matching
 - Back propagation Neural Networks

Online learning (unsupervised learning)

- Sensor data or features are continuously used to learn a context
- Clustering data and labeling clusters
- Useful for changing environments
- Various methods, e.g. Self Organizing Map

- Simple example – User’s favorite place
 - Base station ID as feature
 - Measure every minute the ID
 - “learn” the user favorite place
 - This relates to a time frame (e.g. favorite place over the last month)

Publications

- *S. Sridevi, J. Vimal, S. Irene, G. Dhivya*, "**ChaturKarth**a – A **Context Aware Intelligent Room**", The Fourth IASTED International Conference on ADVANCES IN COMPUTER SCIENCE AND TECHNOLOGY (ACST 2008), 2nd Apr 2008 to 4th Apr 08, Langkawi, Malaysia
- *Vimal Joy, Sridevi S, Vimal Laxman.P*, "**Location Based Services - Enterprise Mobility**", IEEE Wireless Communications & Networking Conference (IEEE WCNC 2008), 31st March 2008 to 3rd April 2008, Las Vegas, USA
- *Vimal Joy, Vimal Laxman.P*, "**Smart Spaces: Indoor wireless location management system**", International Conference on Next Generation Mobile Applications , Services & Technologies (IEEE NGMAST 2007), 12th Sept 2007 to 14th Sept 2007, Cardiff, Wales, UK.

Summary

- Context-aware computing offers many advantages, allowing systems to act more autonomously and take initiative, but informed by a better model of what their users need and want.
 - Building and deploying context aware systems in open, dynamic environments raises a new set of research challenges.
 - Sensor Data Acquisition
 - Context Modeling & Reasoning
 - Service Discovery
 - Execution of services for the user
 - Context Aware Framework will reduce the difficulty and cost of building such context aware systems.
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References

- Albrecht Schmidt. Ubiquitous Computing - Computing in Context
 - <http://www.comp.lancs.ac.uk/~albrecht/phd/>
 - <http://albrecht-schmidt.blogspot.com/>
 - Dey, A.K. and Abowd, G.D. (1999). Toward a better understanding of context and context-awareness. Gvu Technical Report GIT-GVU-99-22, College of Computing, Georgia Institute of Technology.
 - <ftp://ftp.cc.gatech.edu/pub/gvu/tr/1999/99-22.pdf>
 - Context-Aware Applications Survey By Mari Korkea-aho, Department of Computer science, Helsinki University of Technology
 - 'A survey on context-aware system' by Matthias Baldauf and Schahram Dustdar and Florian Rosenberg
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Thank you!
