Context-Aware Computing

Introduction

Credits

Slides based on

Tutorial on Context-Aware Computing

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Context Definitions - Merrian Webster

context

1. the parts of a discourse that surround a word or passage and can throw light on its meaning
2. the interrelated conditions in which something exists or occurs

Context – Schilit, Adams, Want

- Three important aspects of context are:
  - where you are
  - who you are with
  - what resources are nearby

- Context-aware systems adapt according to the location of use, the collection of nearby people, hosts, and accessible devices, as well as the changes to such things over time.
- A system with these capabilities can examine the computing environment and react to changes in the environment.

Schilit B, Adams N, Want R (1994)

Context – Schilit, Adams, Want

- Neglected aspects on previous definition are:
  - who is using the system
  - when the interaction is happening

  as well as
  - why the person/group is interacting
  - how the interaction is happening (e.g., what the person is doing)

Five Ws (and one H)

- In journalism, the Five Ws is a formula for getting the complete story on a subject. The maxim of the Five Ws (and one H) is that for a report to be considered complete it must answer a checklist of six questions
- The principle underlying the maxim is that each question should elicit a factual answer — facts necessary to include for a report to be considered complete.

From Wikipedia, the free encyclopedia – Liberamente rivisto

Five Ws (and one H)

- Who is it about?
- What happened?
- Where did it take place?
- When did it take place?
- Why did it happen?
- How did it happen?

Context - 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
- Context is all about the whole situation relevant to an application and its set of users. We cannot enumerate which aspects of all situations are important, as this will change from situation to situation

Dey (2001) Understanding and Using Context

Context-Aware Systems - Dey

- 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.
- One of the holy grails of context-aware computing is to have applications that do the right thing at the right time for users. While designers who have domain-specific expertise can determine part of the solution, they will obviously not think of everything that is needed to support individual users. It is the end user who is in the best position to further specialize context-aware applications to meet their individual needs.

Dey (2001) Understanding and Using Context

Context – Chen, Kotz

- Context is the set of environmental states and settings that either determine an application's behavior or in which an application event occurs and is interesting to the user.
- Active context awareness: an application automatically adapts to discovered context, by changing the application's behaviour.
- Passive context awareness: an application presents the new or updated context to an interested user or makes the context persistent for the user to retrieve later.

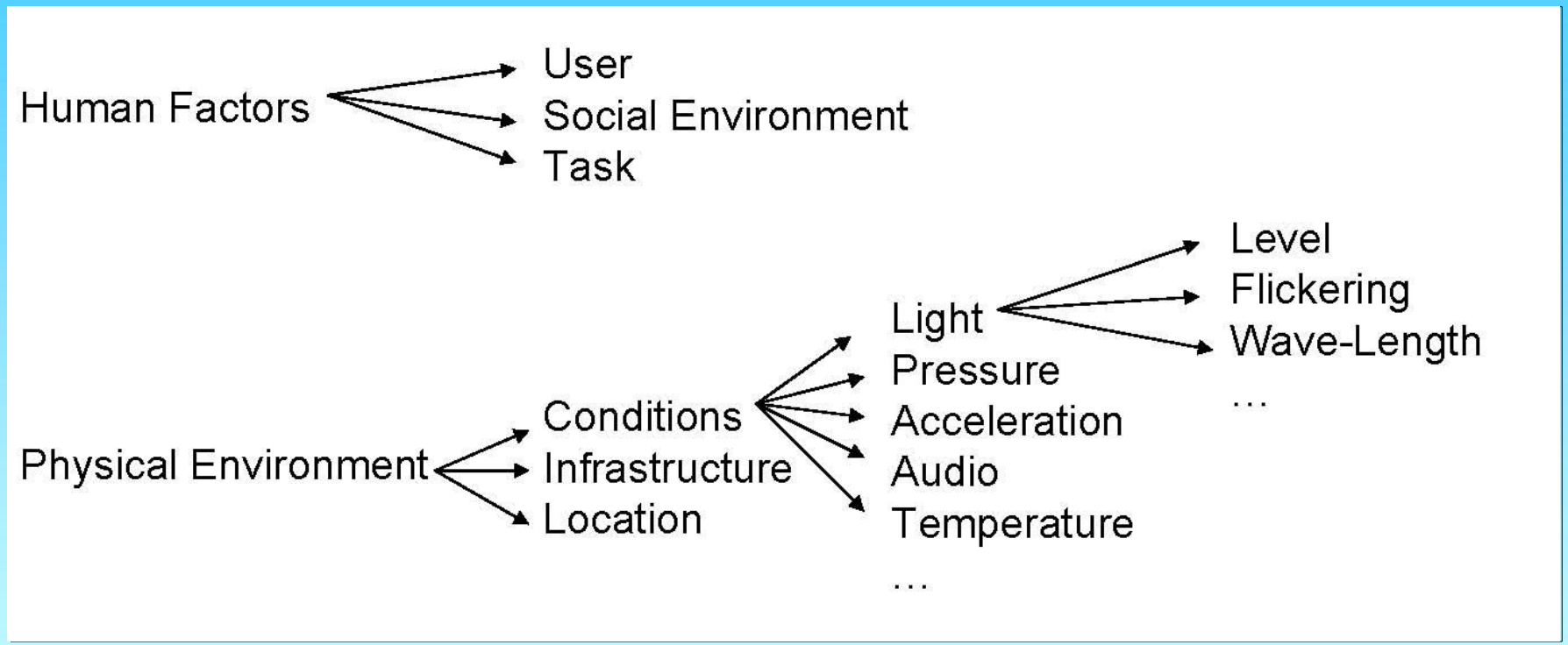
Chen, Kotz: A Survey of Context-Aware Mobile Computing Research (2000)

Context – Schmidt, et al.

- A “working model for context”
- Context describes a situation and the environment a device or user is in
  - Context is identified by a unique name
  - For each context a set of features is relevant
  - For each feature a range of values is determined

Schmidt, et al. There is more to Context than Location (1999)

Context feature space – Schmidt, et al.



Schmidt, et al. There is more to Context than Location (1999)

Context definitions: Summary

- A variety of definitions of context
- Common aspects:
  - Context influences applications (presentation, processing, etc.)
  - Context “data” are dynamic
  - Context includes the “physical environment”

Context definitions: Summary

- The concept is clear but not its boundaries (if any)
- Context controversial aspects (my viewpoint shared by some researchers):
  - Context relevant data change over time
  - Context not only depend on the kind of application but also on the situation (the context itself!)
  - Context (strongly) depends on human factors and social environment (e.g., the user, user's activity and goal, the content of interaction)

Working with Context

- In designing context-aware applications it is useful to group/categorize context data and the focus of context-aware applications in order to:
  - Model data differently
  - Focus the design on a particular aspect/behaviour of the application
  - ...

depending on its category

Context Types – Schilit, et al.

- Computing Context
  - Network connection
  - Communication costs
  - Nearby resources (e.g., displays, printers)
- Physical context
  - Lighting
  - Noise level
  - Traffic conditions
- User context (see next slide)
- User's profile (Coming of age: celebrating a quarter century of user modeling and personalization, 2012)
  - Location
  - People nearby
  - Current activity

Context Types - Roto

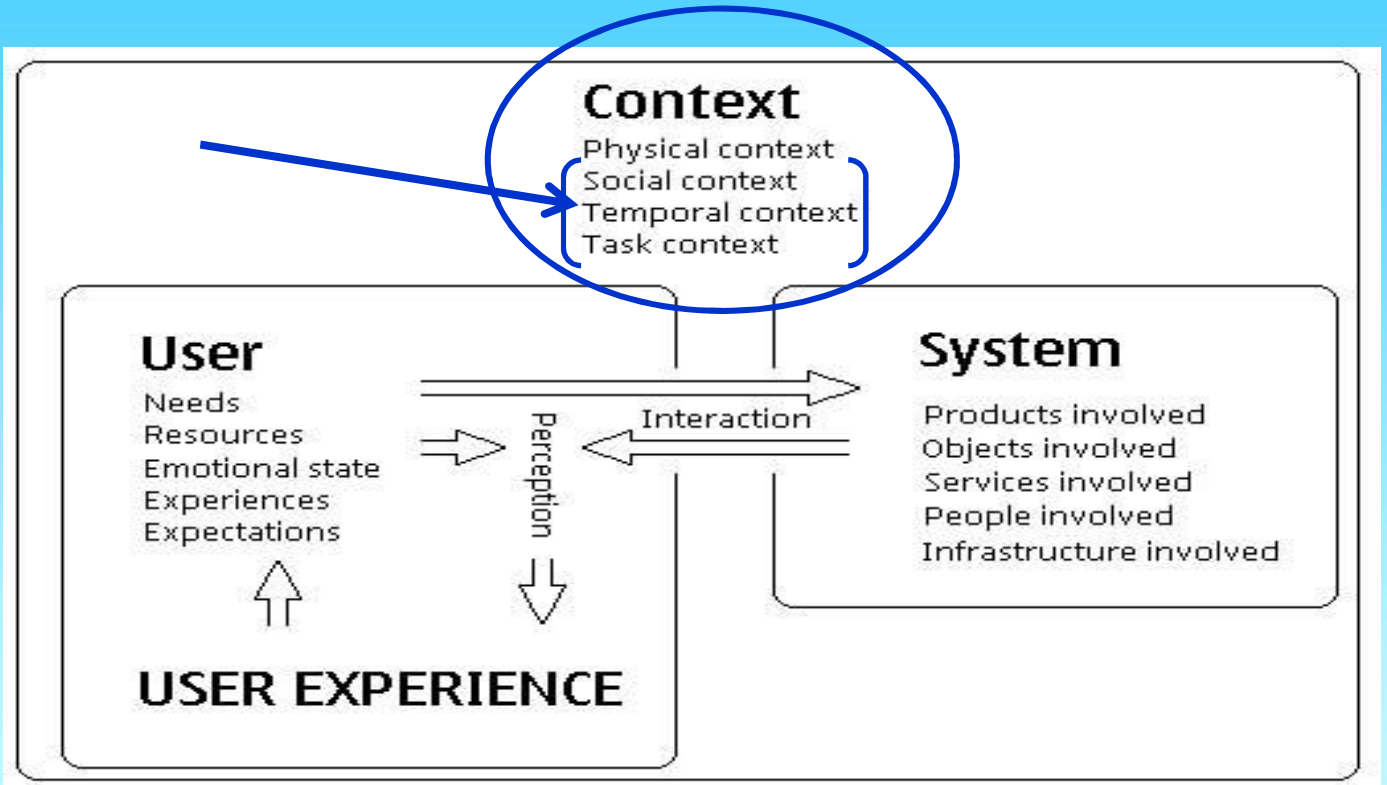
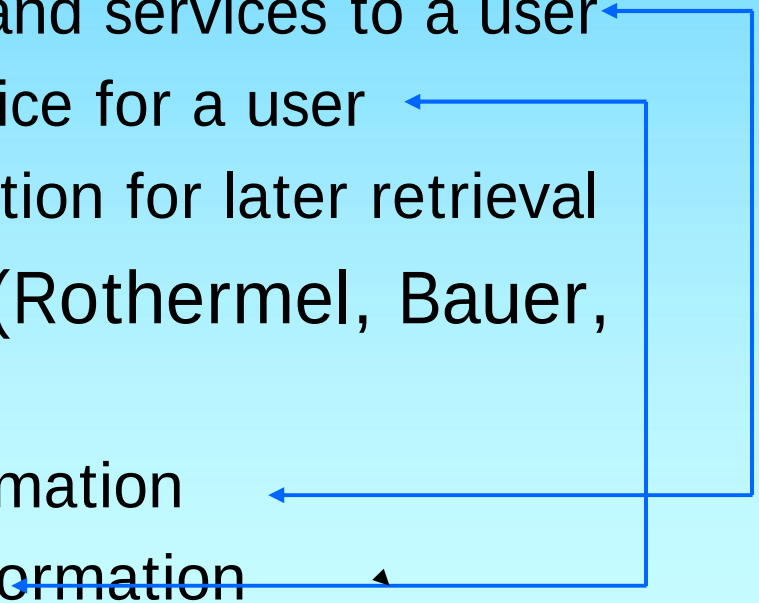


Figure 1. User experience building blocks

Roto V. User Experience Building Blocks (2006)

Categories of Context-Aware Applications

- Four categories of context-aware applications
- Definition by Alain Dey
  - *Presentation of information and services to a user
  - Automatic execution of a service for a user
  - Tagging of context to information for later retrieval
- Defition by various authors (Rothermel, Bauer, Becker)
  - *Selection of services or information
  - Presentation of services or information
  - Action depending on context



Categories of Context-Aware Applications

- Four categories of context-aware applications

Active Context

1. Selection of services and/or information
2. Presentation of information and/or services to a user
3. Automatic execution of a service for a user
4. Tagging of context to information for later retrieval

Passive Context

Examples – 1 Selection

Selection of information and/or services

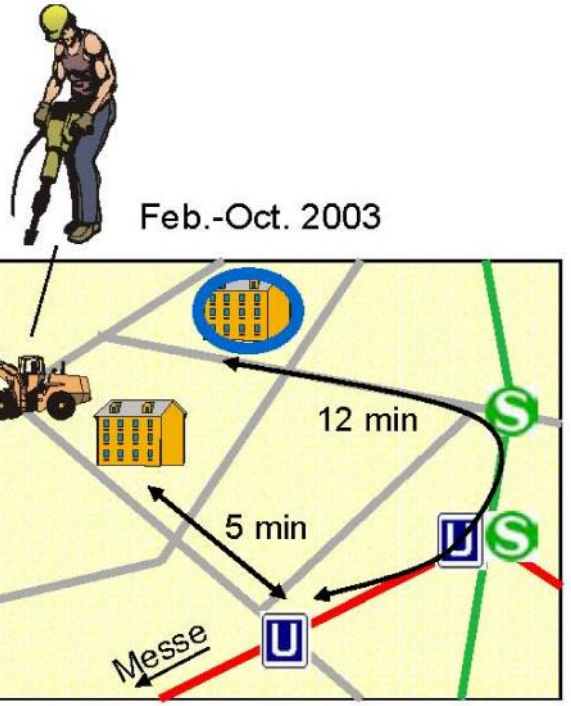
- The (famous :-) next printer
- Classical booking and reservation systems – incorporating context, e.g. hotel, flight, etc.
- Navigation systems
  - Context-dependent restrictions (e.g., avoid stairs for people in wheelchairs)
  - Preferences: prefer elevators over stairs
  - Dynamism: incorporate dynamic information, e.g. traffic jams, crowds of people

Context-aware Selection

Selection of services or information based on context

Example: Hotels within 30 min distance to Stuttgart Fair and in quiet surroundings.

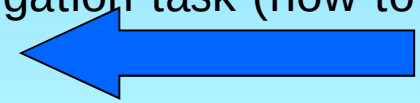
- Context:
  - Location: Hotel, Fair, Connections (roads, public transport)
  - Dynamic information: road constructions
  - Time: construction during Feb. till Oct. 2003



Examples – 2 Presentation

Presentation of information and/or services to a user

- Navigation system (again!)
  - Find a route from A to B
  - Incorporate dynamic information (traffic jams, crowds, ...)
- Location based services
  - Select target based on a specification (restaurant, printer, friend)
  - May lead to an implicit navigation task (how to reach a printer)
- Multi-modal interfaces
  - Change display* depending on
    - Velocity (navigation)
    - Device properties (screen resolution)
    - User preferences (visually impaired)



* intending also video to audio, video to image, image to text, long text to short text

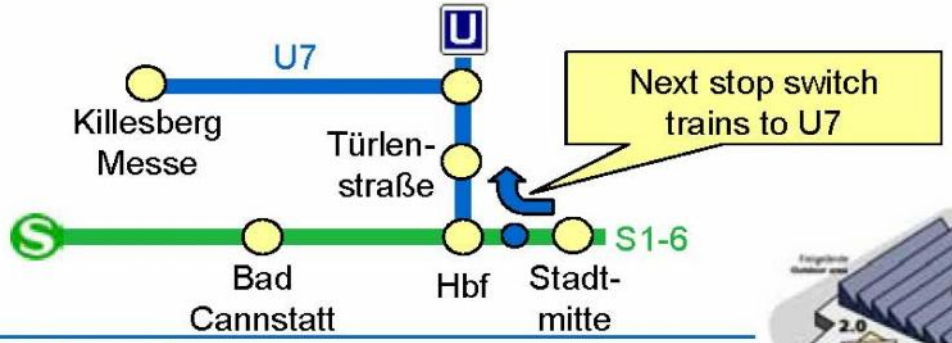
Context-aware Presentation

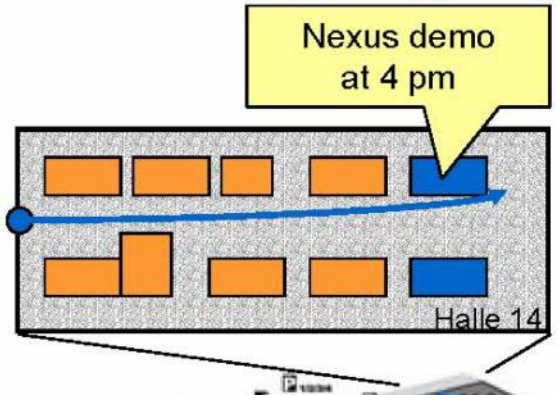
Presentation depending on context

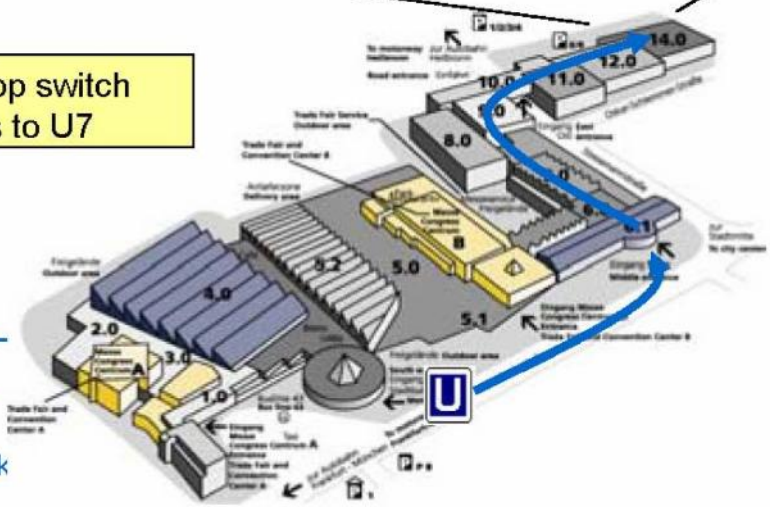
- Level of detail, media, ..

Example: navigation to fair & tour through fair

- Context:
  - Transportation: foot walk, public transport
  - Location: inside/outside hall; within train
  - Preferences, Time: program advises







Examples – 3 Automatic Execution

Automatic execution of a service for a user

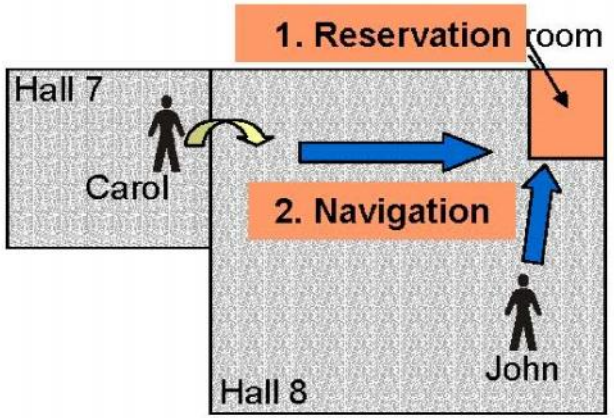
- Sentient computing
  - The physical environment reacts according to user profiles, light, heating, etc.
- Teleporting
  - User interfaces (applications) follow users and use nearest device
- Based on Events (e.g., spatial) (the focus of this course)
  - Action based on a constellation in the physical word
  - Notify(near(shoe shop))
  - OnMeeting(x,y)
  - OnEnter(Paul, Building)

Context-aware Action

Trigger action depending on context (predicates)

Example: Carol enters hall 8 at 10:25; John already present in hall 8. (tentative meeting: 10:00 – 11:00)

- Context:
  - Location: Carol and John in hall 8
  - time: 10:25, i.e. between 10 and 11 am
- Action:
  - Reservation of next vacant meeting room
  - Trigger navigation of Carol and John to the meeting room



Examples – 4 Tagging

Tagging of context to information for later retrieval

- Stick-e Note (1997)
- Smart Doorplates (2003)
- Forget Me Not (1994)
- Virtual Information Towers (VIT) (1999)
- Generally, many CSCW systems (Computer Supported Cooperative Work) providing contextual information to their users (out of the scope of this course);

Stick-e Note (0/2)

- Most context-aware applications can be thought of in terms of attaching objects to particular contexts, so that should the user enter such a context the object will be invoked

Stick-e Note (1/2)

- Similar to Post-It providing information in a convenient or attention-grabbing location
- Attaching objects to particular contexts, so that if the user enter such a context the object will be invoked
- The stick-e Note is defined in terms of the context it is attached to (a place, person, time, etc.) and the content that it represents (information, actions, etc.)

Stick-e Note (2/2)

- The context within the stick-e note indicates the trigger-condition for which a note is invoked
- The context in which a note is required to trigger may consist of many conditions, requiring a compound context, e.g.:
  - Trigger a ‘go to the beach’ note if the location is the computing laboratory, it is a weekend and the temperature is above 25°

Smart Doorplate: services (1/2)

- Doorplates are able to:
  1. Display current situational information about the office owner
  2. Direct visitors to the current location of the office owner based on a location-tracking system
  3. Act instead of the office owner in case of absence

Smart Doorplate: two scenarios of use (2/2)

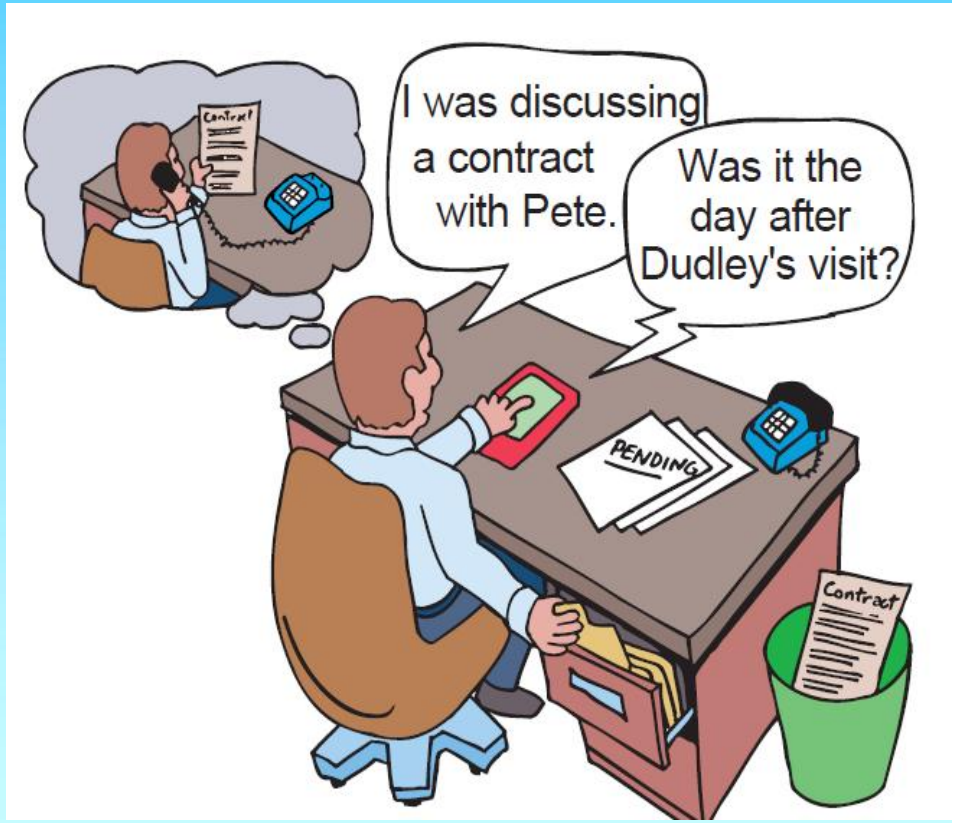
1. Visitor arrives in absence of office owner: the doorplate may display his current location and the time at which he is expected back (the surrounding doorplates are used as direction pointers). The visitor may leave an oral or written message at the doorplate
2. Return after absence: The doorplate recognises the office owner and displays the number of visitors that left a notice. The display must be configurable to meet the individual needs of the office owner

Forget-me-not: human episodic memory

- An attempt to improve computer-based support for human memory
- Forget-me-not is a memory aid designed to help with everyday memory problems
- It exploits the human episodic (or autobiographical) memory to provide alternative ways of retrieving information

Forget-me-not: human episodic memory

- Context as a Retrieval Key:
  - Our memories organize past events into episodes
  - The location of the episode, who was there, what was going on, and what happened before or after, are all strong cues for recall



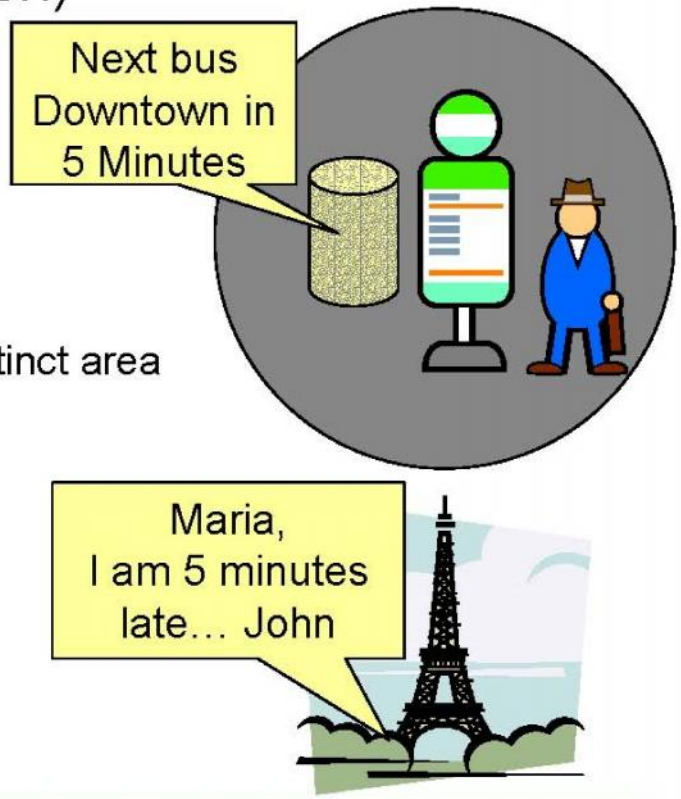
Forget-me-not: Intimate Computing

- Possibly a wearable gadget:
  - involved in many of your activities, intimately familiar with them, adapt to them like a personal assistant
- The more it knows about you, the greater its potential value to you.
- Intimate computing provides your computer with access to your real context

Tagging of Information to Context

Applying virtual objects (information) to physical objects

- Examples
  - Virtual Information Towers
    - Present information relevant for a distinct area
    - Context: location
  - Virtual Post Its
    - Attached to a location
    - Provide information for distinct users
    - Context: location and identity



Summary

- A common (intuitive) understanding of context
- Different definitions of context and types available
- Four categories of context-aware applications
  - Selection of information and services to a user
  - Presentation of information and services to a user
  - Automatic execution of a service for a user (Action)
  - Tagging of context to information for later retrieval
- Notion of primary/secondary context depends on application domain
- User, activity and human/social context may be more important than time and location

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