Introduction

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Contextualized Computing and Ambient Intelligent Systems

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1 Required Reading

1.1 Week 1

Assignment 2.1: M. Weiser

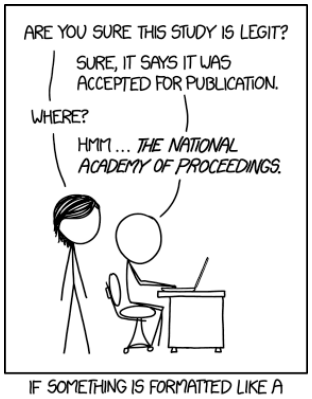
- Required reading for week 1
  - Weiser, M. (1991). *The computer for the 21st century*. Scientific American, pages 94–104.
- The text will be discussed in the tutorial 23.04.2018
- Course readings can be downloaded in the learnweb
- Every text has a wiki-page in the learnweb
  - Use it to describe the text
  - Use it to link the text to the course
- Results of the discussion may also be written up

1.2 Academic Literacy: Reading

Academic Literacy: Reading
. . . if needed

General Structure

- Title
- Abstract
- Introduction
- Methods
  - Analysis
  - Design
  - Implementation
- Results
  - Evaluation
- Discussion/Conclusions
  - Further Works
- Acknowledgements
- References

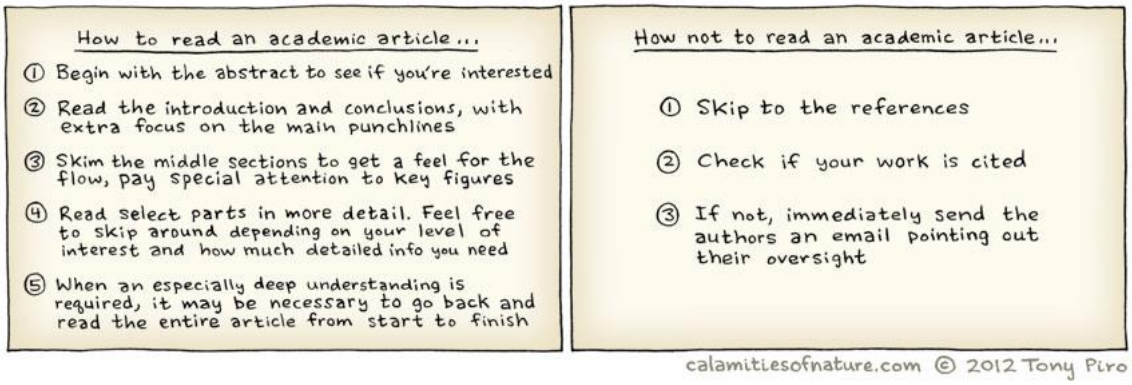


IF SOMETHING IS FORMATTED LIKE A SERIOUS SCIENTIFIC PAPER, IT CAN TAKE ME A WHILE TO REALIZE IT ISN'T ONE.

☞ xkcd: dubious study

Skim & Read

- Do not read from start to finish
  1. Abstract
  2. Conclusions
  3. Introduction
  4. "the rest"
- Whether you continue with the conclusions or the introduction depends on your familiarity with the topics. . . and on the length of the sections



☞ Calamities of Nature

Skim, Re-Read, Examine, Summarize

- Another approach championed by Natalia Rodriguez
- Four steps
  - Skim
    - Read for "big picture"
  - Re-read
    - Examine graphs, tables, figures
    - Interpret the data yourself
  - Examine
    - What problems are addressed?
    - Why is it important?
    - Is the method good?
  - Summarize
    - Write a summary of key point in own words
- ☞ Elsevier Connect, ☞ research4life.org

Three Pass Reading

- Read the Paper in three passes
  1. Quick scan to get a bird's-eye view of the paper to be able to answer the five C:
     a) Category: What type of paper is this?
     b) Context: Which other papers is it related to?
     c) Correctness: Do the assumptions appear to be valid?
     d) Contributions: What are the main contributions?
     e) Clarity: Is the paper well written?
  2. Read the paper with greater care, but ignore details such as proofs

    - Afterwards, you be able to summarize the main thrust of the paper, with supporting evidence, to someone else
  3. Attempt to virtually re-implement the paper
    - Making the same assumptions as the authors, try to re-create the work

- ☞ S. Keshav: How to Read a Paper

What to Look For

- Five elements to look out for:
  1. A significant question or claim
  2. A position in the academic debate
  3. An explanation of the research method or approach
  4. A presentation of the findings and argument
  5. A statement of the implications and contributions of the research study
- You should also aim to place a journal article within the broader academic debate
- ☞ Nicholas Carah and Eric Louw: Guide to reading journal articles

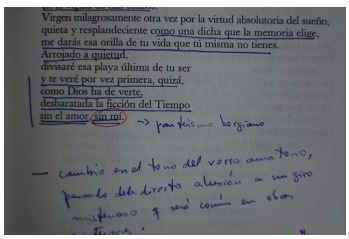
Paper on Reading Papers

RV Subramanyam
"The reader should begin by reading the title, abstract and conclusions first. If a decision is made to read the entire article, the key elements of the article can be perused in a systematic manner effectively and efficiently. A cogent and organized method is presented to read articles published in scientific journals."

Subramanyam R V. Art of reading a journal article: Methodically and effectively. *J Oral Maxillofac Pathol [serial online]* 2013; 17:65-70. Available from: http://www.jomfp.in/text.asp?2013/17/1/65/110733

Notes & Annotations

- Annotations
  - The paper advantage
  - Notes, marks, scribbles, Post-Its are sign of active, creative examination of the content
- Notes
  - Never read a text without pen & paper



cc by-nc Manuel Sanfuentes


cc by Kristian D.

Excerpts

- Reproducing parts of a text
- Paraphrased or word-by-word
- WordNet synonyms: excerpt, excerption, extract, selection

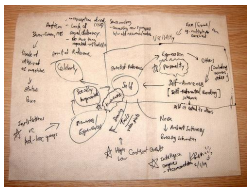
1. Orientation
   - Get a grip of the structure of the text
2. Excerpt

- Work with the text – “what is the contribution of this part of the text?” and “what are the main points made?”

3. Compact
   - Summarize the texts and the excerpts

Visualisation

- Visualisation
  - Mindmaps, Concept Maps, . . .
- Individual preferences



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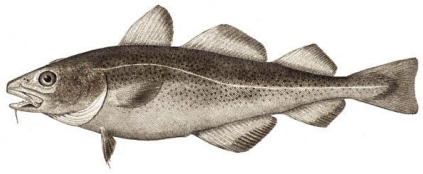

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2 Contextualised & Ambient Computing

Video 2.1: Microsoft Health

☞ Microsoft: Health Future Vision (4:07)

Video 2.2: Microsoft Productity

☞ Microsoft: Productivity Future Vision (2011) (6:18)

2.1 Mediality, Codality & Modality

Focus

We can describe media and interactivity with different foci

- **Presentation** & Recording
  - The “technical side”

  - Means for input and output
  - Devices such as microphones, cameras, loudspeaker
- **Coding**
  - The "meaning" side
  - The representation
  - What signs are used for the information?
- **Perception** & Production
  - The "human side"
  - What senses are used?

Tiers: Example

- **Presentation/Recording – Mediality**
  - Radio: mono-medial
  - TV: multi-medial
- **Coding – Codality**
  - Text only, graphics only: mono-codal
  - Mixed: multi-codal
- **Perception/Production – Modality**
  - Only making use of eyes: mono-modal
  - Making use of eyes and ears: multi-modal

Problem: Different use in different contexts and disciplines

Mediality, Codality and Modality

Multi-mediality: Systems that make use of different media types (such as text, images, video) are called *multi-medial* systems

Multi-codality: Systems that encode the same information in different representations are called *multi-codal* systems

Multi-modality: Systems that make use of different sensual channels for input or output in a coordinated and parallel fashion are called *multimodal* systems

- Mediality: focus on technical presentation
- Codality: focus on semantic representation
- Modality: focus on human senses

Ambient Media

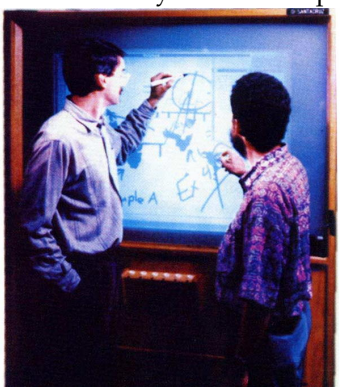
- Digital media become ubiquitous and are available always and everywhere
- Traditional computing systems are bound to keyboard, mouse/touch and displays
  - Written text input
  - Pointing input
  - Written text and visual output
- Change towards availability on a range of devices that are increasingly (at least partly) "backgrounded"
- The "new" paradigm of computing is often called **Ubiquitous** or **Ambient Computing**
  - Multitude of devices per user
  - Computers often not visible
  - Interaction moves from explicit to implicit

2.2 Ubiquitous Computing

Ubiquitous Computing

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." (Weiser [1991], *The Computer for the 21st Century*)

"This then is Phase I of ubiquitous computing: to construct, deploy, and learn from a computing environment consisting of tabs, pads, and boards. This is only Phase I, because it is unlikely to achieve optimal invisibility."



(Weiser [1993], *Some Computer Science Issues in Ubiquitous Computing*)

Similar Concepts

- **Ubiquitous Computing**: focus on everywhere and disappearing computing
- **Ambient Intelligence**: similar use, but more focus on AI aspects
- **Pervasive Computing**: often with focus on (IT) architecture
- **Internet of Things**: focus on connectivity of devices, sensor and actuator networks
- **Mobile Computing**: focus on small devices that are still visibly computers
- **Wearable Computing**: computers as part of clothing
- **Contextualised Computing**: taking the situation the user is in into account

2.3 Context

Context

- We generally refer to intelligent behaviour as being contextually appropriate.
- An ability to accurately read context is important for any animal if it is to survive, but it is especially important to social animals.
- In humans, such an ability is tightly linked to reasoning and cognition [Cohnitz, 2000; Leake, 1995].
- A situation is a confused, obscure, and conflicting thing, that a human reasoner attempts to make sense of through the use of context.

Operational Model of Context

- Positions on context tend to fall into two broad domains: those who see context as vast and unable to be coded and those who see it as vast but able to be coded.
- The pragmatist approach can be described through the following statements about context [Ekbia and Maguitman, 2001]:
  - Context, most often, is not explicitly identifiable.
  - There are no sharp boundaries among contexts.
  - The logical aspects of thinking cannot be isolated from material considerations.
  - Behaviour and context are jointly recognisable.

Working with Context

Context Awareness
Trying to **detect** the situation the system is in.

- **Example:** An ambient intelligent system for supporting health personnel figures out that the user is on a ward-round because of the time of the day, the location, and the other persons present.

Context Sensitivity
Acting according to the situation the system thinks it is in.

- **Example:** the same system fetches the newest versions of electronic patient records of all patients in the room from the hospital systems. When the user stands close to the bed of a patient, the system automatically displays them.

Best Practice Context Models

- **Environmental context:** This part captures the users surroundings, such as things, services, people, and information accessed by the user.
- **Personal context:** This part describes the mental and physical information about the user, such as mood, expertise and disabilities.
- **Social context:** This describes the social aspects of the user, such as information about the different roles a user can assume.
- **Task context:** the task context describe what the user is doing, it can describe the user's goals, tasks and activities.
- **Spatio-temporal context:** This type of context is concerned with attributes like: time, location and the community present.

2.4 Ambient Intelligent Systems

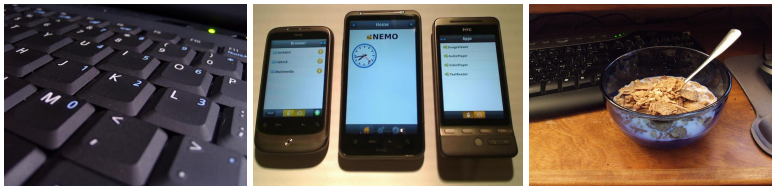
Ambient Intelligent Systems

> At the core of an ambient intelligent system lies the ability to **appreciate the system's environment**, be **aware of persons** in this environment, and **respond intelligently to their needs** (Ducatel et al. [2001], *ISTAG Scenarios for AmI in 2010*).

- **Perception:** The initial act of perceiving the world that the system inhabits
- **Context Awareness:** Being aware of the environment and reasoning about ongoing situations
- **Context Sensitivity:** Exhibit appropriate behaviour in ongoing situations
- **Action:** Changing the environment according to context

Ambient and Other Systems

- Ambient Systems will not replace, but augment existing systems and their interaction capabilities
- Examples:
  - Location-based services can enhance the usefulness of existing systems
  - An ambient system might "fall out of ambience" if something goes wrong



Video 2.3: Amigo Project

☞ Amigo Project (9:44)

Descriptive Framework Version 1

Contextualisation

- Contextual Parameter
  - Environment – things, services, people
  - Personal – mental & physical information about user
  - Social – roles & relations
  - Task – what is the user doing
  - Spatio-Temporal – when & where are we
  - Other
- Kind of Contextualisation
  - Awareness – what aspects are taken into account?
  - Sensitivity – what aspects are changed?

Descriptive Framework Version 1

Ambience

- Perception
  - Mediality – media types
  - Codality – semantic representation
  - Modality – human senses
- Reasoning
  - *Context Awareness*
  - *Context Sensitivity*
  - Other
- Action
  - Mediality – media types
  - Codality – semantic representation
  - Modality – human senses

3 Tutorial

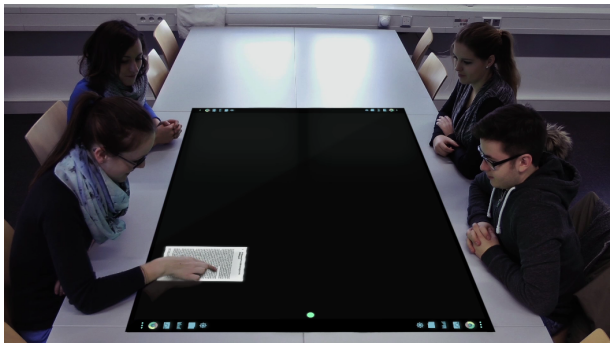
Assignment 2.2: Collecting Examples

- For the next two weeks, you should collect interesting examples of ambient or contextualised systems you come across
- You should use the framework introduced to describe the different systems
- You should be able to present one or two examples
  - Classification according to the framework
  - Shortfalls of the framework
- Deliverable:
  - Monday, 23.4., 18:00, learnweb
  - Monday, 23.4., in the course

Assignment 2.3: Project Idea

- Form groups of 3-6
- Develop the outline of a project idea which would implement a contextualised and/or ambient system
- Possible application area:
  - University 2028
- Possible technologies:
  - Tangible interfaces
  - Behavioural interfaces
  - Large multitouch displays
  - Natural language processing
- Pitch your idea in the course

Video 2.4: Universität 2025



☞ Where VR in 2025 (6:45)

Assignment 2.4: Deficits

- Based on your experience with the previous assignment
  - What were the main obstacles when doing the task?
  - What knowledge or experience do you think is missing?
  - What gaps should be filled with this course?
- Start building your own map of the subject area

Assignment 2.5: Aarts, Harwig & Schuurmans

- Required reading for week 2
  - Aarts, E., R. Harwig, and M. Schuurmans. 2001. Ambient Intelligence. In *The Invisible Future: The Seamless Integration of Technology into Everyday Life*, ed. P. J. Denning, pp 235-250. New York: McGraw-Hill Companies.
- The text will be discussed in the tutorial 30.04.2018
- Course readings can be downloaded in the learnweb
- Every text has a wiki-page in the learnweb
  - Use it to describe the text
  - Use it to link the text to the course
- Results of the discussion may also be written up

4 Research Systems

4.1 ShareBoard

ShareBoard

- Tools for cooperation and collaboration of teams in one location as well as across different locations
- Main tool: shared electronic whiteboard (ShareBoard)
- Goal: to deliver a "Natural User Interface" to working with electronic whiteboards, making use of past user experiences and taking the context of use into account
- Test case for ambient interactive spaces
- Supports both pen- or touch-based interaction and interaction with mouse and keyboard as well as any combination thereof
- Input devices to recognise the movement of users in the surrounding space and for sensing 3D-gestures

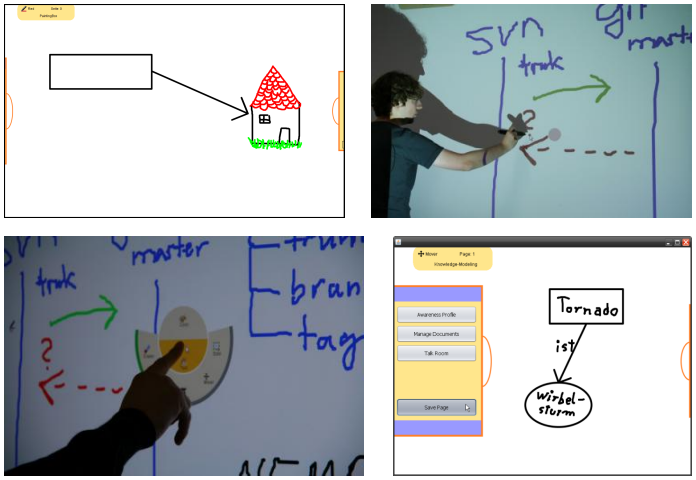
Starting Point

- There are a number of existing electronic whiteboards, but most have some shortcomings
  - Focused on tangible interfaces, but lacking in tools for remote collaboration (e.g. SmartBoard)
  - Focused on remote collaboration, but lacking in tangible interfaces (e.g. Adobe Connect)
  - User interfaces often not adopted to size of whiteboards
    - Menus on top of the screen are not ideal on whiteboards
- ShareBoard:
  - Interface well suited for large tangible interfaces
  - Interface for mouse, pen- or touched-based PCs
  - Integrated tools for audio and video communication
  - Contextualized use and explicit interaction
  - Developed in a user-centric, feature-based process
    - New feature sets defined and developed independently
    - Feature sets based on user feedback and implemented with the help of ongoing user testing

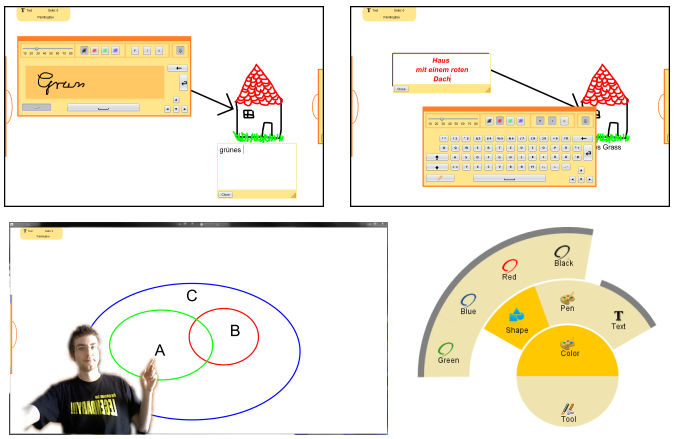
Principles

- Building on top of existing projects
- Easy and cheap to use electronic whiteboards
  - Touchscreen or
  - video projector and screen
  - Wii remote controller and IR-Pen
  - Laptop with Webcam
  - Optional: kinect-like controller, leap motion controller
- Drawings on canvases
  - Freeform
  - Shapes
  - Text (handwriting, virtual keyboard, speech recognition)
- Audio and video communication with other parties
  - Automatic recognition of turn taking

Example: ShareBoard



Example: ShareBoard



ShareBoard: Ongoing

- How can we enable multimodal/multicodal communication at a distance when using electronic whiteboards?
- How can we implement multicodal interfaces with ambient systems?
- How can the ShareBoard understand the context of situation and adapt its behaviour to support it?
- How do people interact with each other when using electronic whiteboards
  - Locally (computer as a tool)
  - Remotely (computer mediated)
- Porting ShareBoard from Java to "HTML5" (html, css, JavaScript) with "almost" feature parity
  - A usable version is ready for further development
  - Using Meteor.js, Angular2.js, mongodb, node.js

4.2 PerGamEn

PerGamEn

Pervasive Games & Environments

- Pervasive (Learning) Games & Environments
- Breaking the magic circle, extending
  - spatial
  - temporal
  - social

  boundaries of game play
- This media informatics research area is still starting up
- First examples
  - *Find It* – Learning by Caching
  - *City Explorer* – Discover Würzburg
  - *Uburzis* – competitive location-based game for school teams
- All designed and implemented taking instructional psychology into account
  - Serious Games – gaming with a learning goal

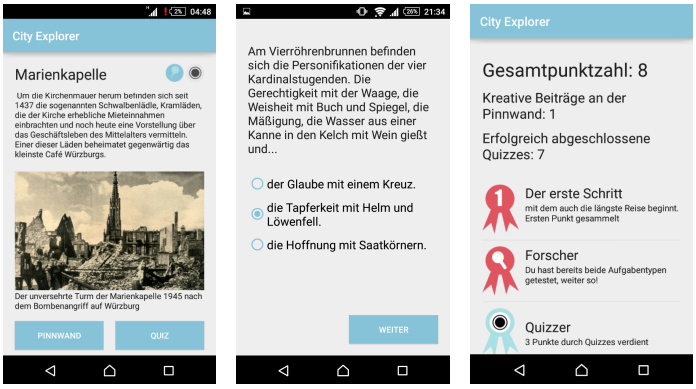
Find It – Learning by Caching

- Mixture of geocaching and language learning
- Going to different sites where you can find vocabulary
- Tests contextualized (primarily) to the location
  - Near a café? Order something to eat
- Team learning by challenges

City Explorer – Discover Würzburg

- Explore landmarks, museums, places in Würzburg
- Information screens for the different landmarks and points of interest
- Score points for completing missions
- A mission contains of different tests
  - Answer questions where information available at the location is needed
  - Write a text
  - Draw something
- Uploaded and commented upon by other users

City Explorer – Screenshots



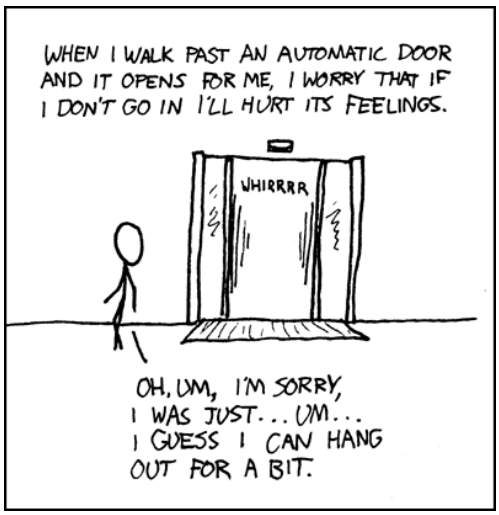
Uburzis

- Two teams (school classes) compete
- A course through Würzburg to specific landmarks
- Questions relying on information available on site
- A team can capture a site by answering the question
- Re-capture by another team by answering more complicated questions

4.3 Sliding Doors

«SlidingDoors»

Automatic Doors



xkcd.com/175

Trouble with Doors

Apart from when walking through doorway when it must be opened.

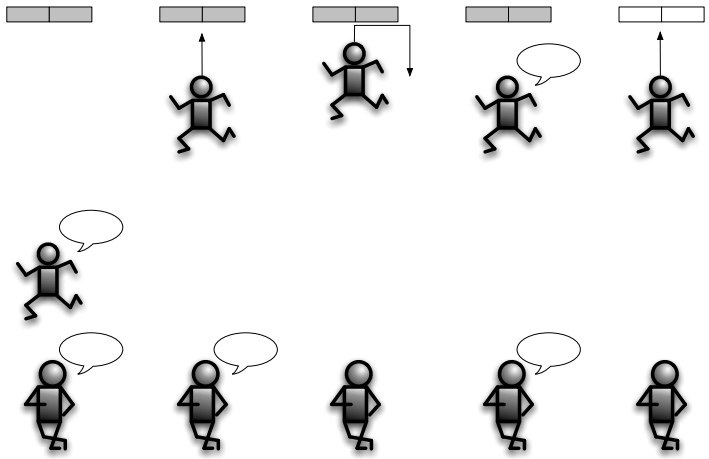
Star Trek Doors Fail

Making Sense

- One challenge for ambient intelligence: embed technical artefacts into human processes in such a way that they support the sense making processes of human actors instead of placing new burdens upon them

- This successful integration requires an operational model of context
  - and an appropriate mental model of the system by the user
    - unless it truly disappears
- Particularly important for disambiguating abstract concepts that have no clear grounding in the material setting of the work process

Star Trek Doors



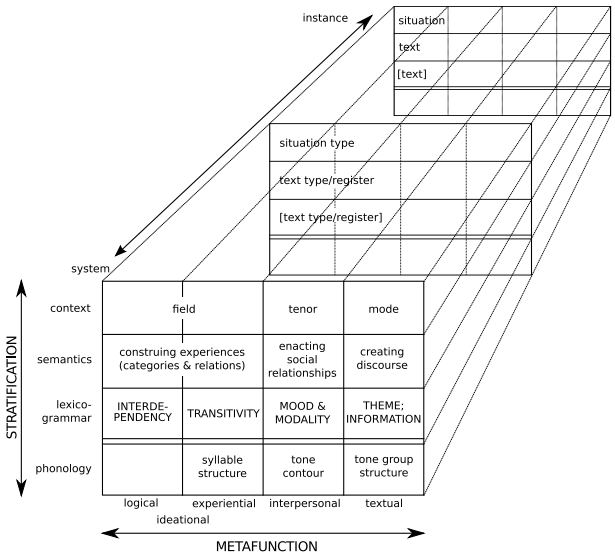
Multimodality

- Truly smart applications need to interface with the **behaviour** of human and non human actors in their surroundings.
- Systems with such interfaces have the potential of supporting those with non standard communication practices
  - the elderly living alone,
  - people with disabilities,
  - and many others.
- While the benefits are clear, the means of achieving true behavioural interfaces are more difficult.
- Question: how are different modalities across different strata related?

Dimensions of Language

Semantics

- Semantics as meaning potential or "what the person can mean" [Halliday, 1979, p.72]
- Think of behaviour as semantic since there is a set of behaviours that are at the individual's disposal within a particular context
- There is a limit to how truly individual it can be in most social contexts if the intention is to share meaning
- To share meaning you must share the code
- **It should be possible to model the meaning potential available in a particular context**
- Because communicating is multimodal, intention will not always be signalled entirely by behaviour
- The task in modelling intention is to find (patterns of) behaviours which carry the most significant meaning



Dimensions of language [Halliday and Matthiessen, 2004].

Behaviour in Context

- How behaviour creates meaning and how we assign meanings to behaviour is significantly related to situation and context
- Meaning is constituted in the interaction between the behavioural sign and its function within a context
- It is important to see expressive action as part of context and not as the product or effect of context
- We can only assign meaning to behaviour through its interaction with the context in which it is embedded
- If we are to find meaning in behaviour we primarily look to the dynamic relationship between the unfolding interaction and the context

Intention in Context

- Intention is something which is dynamic and emergent from interaction rather than a static and predetermined feature of interaction
- Intention can thus be considered context sensitive
- We have not attempted to model intention as a general or context free concept
- We have looked at the intention to walk through a door rather than intention in general
- Our model of intention may be generalisable to contextually similar situations (waiting for a bus or train)

Sliding Doors

- Automatic sliding doors were chosen because of a rather restricted behavioural set
- Also, link between behaviour, intention and outcome is much clearer and simpler than in other typical, but more complex situations
  - The doors either open appropriately or they do not
- We were in no way suggesting that automatic doors should respond to intention
  - Proximity is a good approximation of intention to go through a door
- But other people thought it would be good, so we reconsidered that position

Machine Readable

- Intention to walk through a door chosen as a means of testing the viability of coding behaviour in a way that it "means" something for machines as well as humans
- Behaviours associated with showing intention to walk through a door are relatively coarse grained and emerge from very few behavioural features
- Allow us to test the model without having to control too many elements
- We compare the behaviour of people walking through a door with that of people standing near a door and talking or waiting

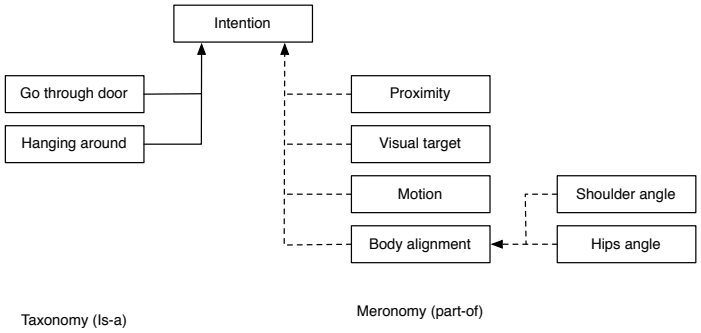
Features

- Drawing on Moore [2008], we have focused on the representation of *body alignment*, *proximity* and *visual target*
- These three features of human behaviour have been associated with the interpersonal function of communication
- Body alignment is made up of a number of different measures and is made relative to the doors
- Because there is an unstable relationship between body angle and visual target, we have discarded visual target
- To this we have added a further measure of *dynamism*

Features (contd.)

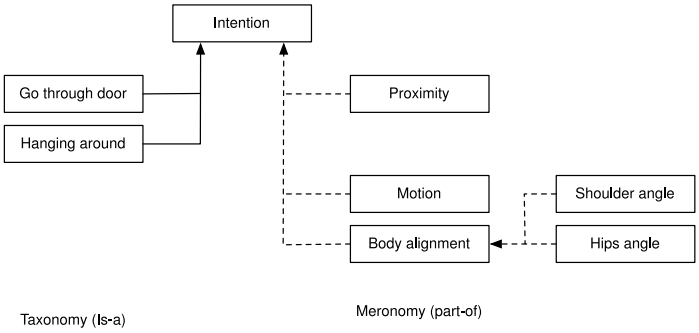
- Measurements for body alignment used are angle of shoulder and hips to the point of origin
- When showing intention to walk through a door people have their shoulders and hips aligned approximately square to the door
- Those engaged in conversation or waiting typically stand with shoulders and hips perpendicular to the door and in the case of conversation, square or obtuse to their conversation partner
- We use movement to discriminate between people walking away from the door and towards the door and those standing with their back to the door

Model



Intentions and behavioural features [Kofod-Petersen et al., 2009].

Model II



Intentions and behavioural features [Kofod-Petersen et al., 2009].

Test System

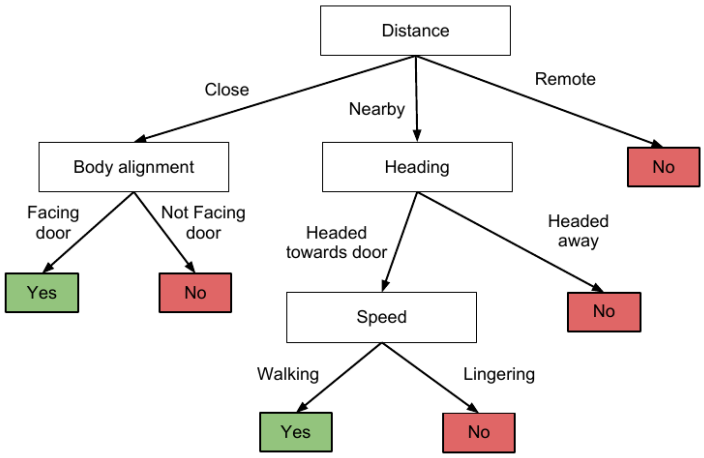
Built as part of the Masters thesis of John Sverre Solem

Demo Run

John Sverre Solem: Intention-aware Sliding Doors. Masters Thesis, Norwegian University of Science and Technology. 2011.

Håvar Aambø Fosstveit: Intelligent Sliding Doors. Masters Thesis, Norwegian University of Science and Technology. 2012.

Reasoner



Decision tree visualization of a rule base [Solem, 2011].

Evaluation: Method I

- Two aspects:
  - How well does the door perform compared to a traditional sliding door?
  - How well does the door perform compared to the real intention?
- Test using Manuscripts (Scenario-based evaluation)
- Including cases where the door should open and cases where it should remain closed
- Manuscripts define specifics concerning speed, acceleration, path, number of actors and intention
- **15 different manuscripts, 390 test-runs**

Evaluation: Method II

- **Accuracy (ACC):** Comparing correct actions to the total number of actions.
- **Sensitivity/True positive rate (TPR):** Is it opening when it should? TP compared to all positive intentions.
- **Specificity/True negative rate (TNR):** Is it opening when it should not? TN compared to all negative intentions.
- **Positive predictive value (PPV):** How good is the system at predicting positive intentions? Precision rate, TP compared to all test positives.
- **Negative predictive value (NPV):** How good is the system at predicting negative intentions? TN compared to all test negatives.

Evaluation: Results I

Sensitivity/True positive rate (TPR)
Traditional doors: 100.0 %
Intentional doors: 70.4 %

Specificity/True negative rate (TNR)
Traditional doors: 0.0 %
Intentional doors: 90.0 %

Sensors had sometimes difficulties in detecting features

Evaluation: Results II

Sensitivity/True positive rate (TPR)
Traditional doors: 100.0 %
Intentional doors: 84.2 %

Specificity/True negative rate (TNR)
Traditional doors: 0.0 %
Intentional doors: 88.6 %

Perfect sensors assumed

Sliding Doors: Ongoing

- Based on the initial results, several follow up projects were started
  - Automatic Traffic Lights (Norwegian Road Authorities)
  - Automatic walking chair
- Basic modeling work flow and framework has been adapted for other research
  - Currently: Understanding the intentions of lecturers in a teaching situation
  - Goal: Deliver contextualized, on demand summarisation of video lectures

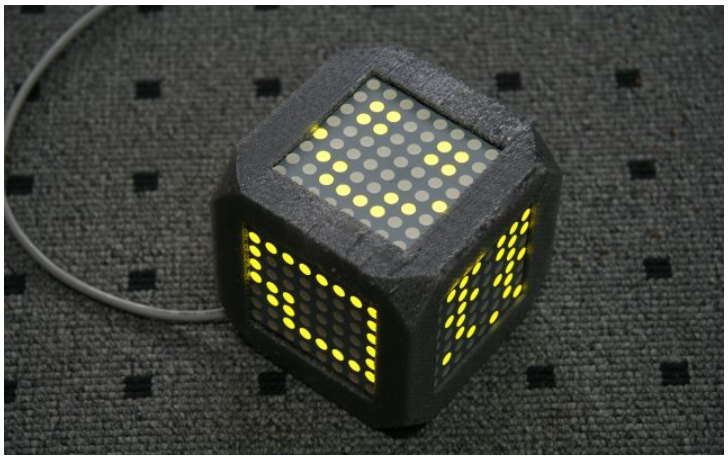
4.4 CAKE

CAKE and MATe

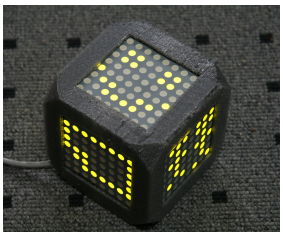
- CAKE (Context Awareness and Knowledge Environment) is a *framework* for building contextualized ambient intelligent systems
- MATe (Mate for Awareness in Teams) is an *application* primarily aiming at improving situation awareness in work teams
- Designed to blend seamlessly with the team members' everyday routine, enabling unobtrusive in-situ interaction and facilitation of cooperation and communication
- Knowledge is modelled in a user-centred process
- Technologies employed come from the semantic web community as well as artificial intelligence in general and machine learning in particular

Example: MATe

Example: MATe Cube



Example: Exploring the Design Space



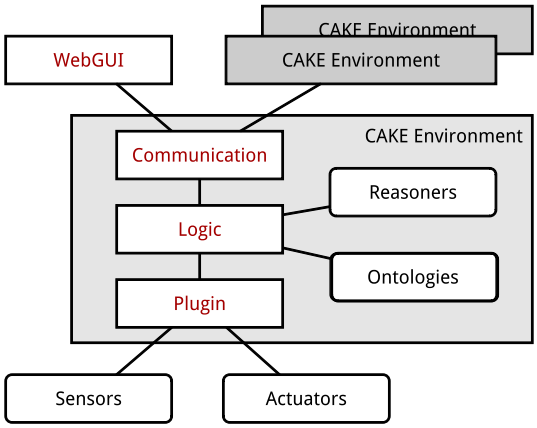
Very ambient, but hard to understand?
Very traditional, but easy to grasp?
Or something in between?

CAKE: Goals

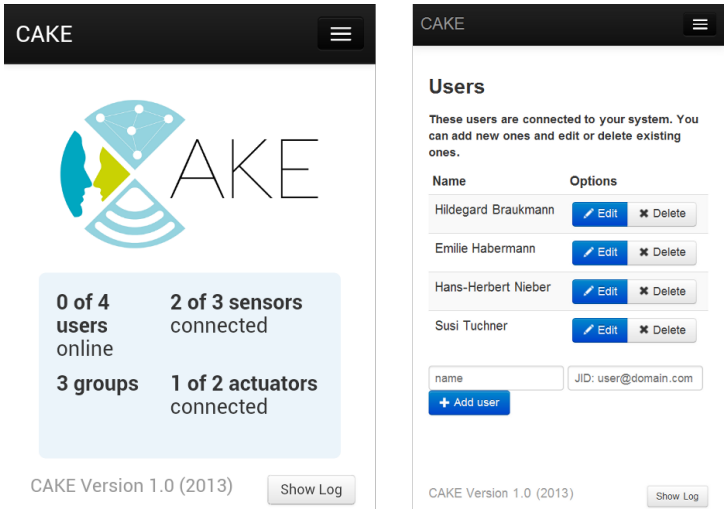
The following goals were central during development:

- Flexibility with regard to sensors and actuators
  - Easy for developers to write new software components
  - Easy and safe for users to add new components
- Flexibility with regard to the reasoning engines used
- Reusability of sensors and actuators across different domains, where applicable
- A decentralized architecture that would allow every user to run his or her own context-aware environment to address concerns about sharing raw data
- Fine-grained and coarse-grained control for access to information to address further privacy concerns
- Feature parity with the existing system (at the time, MATe built with the MACK framework)

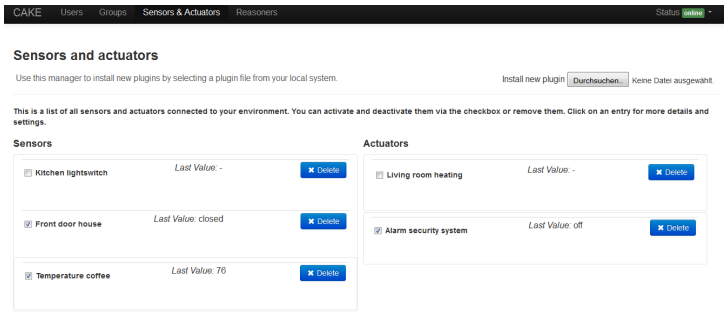
CAKE: Architecture



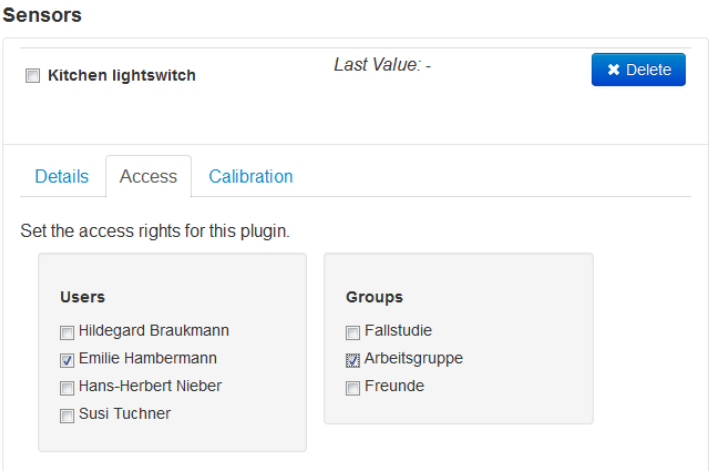
CAKE: Mobile GUI



CAKE: Sensor/Actuator Management



CAKE: Sensor Details



4.5 LADI

Convergence Problem

- Users have access to a diverse set of computerized systems
  - Desktop computers

  - Mobile phones
  - Game gadgets
- Each systems has different capabilities
  - Presentation and processing
  - Interaction paradigms
  - Storage
  - Connectivity

This variety poses a problem for the envisioned convergence of media within a single personal or social information space

Smartphones

- Mobile phones (smartphones) have computing and storage powers that exceed recent personal computers
- Considered very personal items and often carried around
- A token indicating the location of the user
- Smartphones are often connected to the Internet permanently, making them
  - a premier point of access to data stored in the cloud or
  - tokens to interact with other systems
- From a user perspective, it should not matter what network the devices are actually connected to
- The personal phone offers a familiar user interface

Scenario

- Alice is a lecturer at a university
- Preparing slides for a talk in her research group
- Saves the resulting PDF-file in "the cloud"
- When Alice arrives, her smartphone recognizes her position when she arrives at the meeting room
- Several computers available
- She selects the desktop computer on her smartphone and the system migrates the slides to this machine
- Alice is able to use her smartphone to navigate through the presentation
- She can use her phone to access other multimedia objects in cloud-based storage solutions

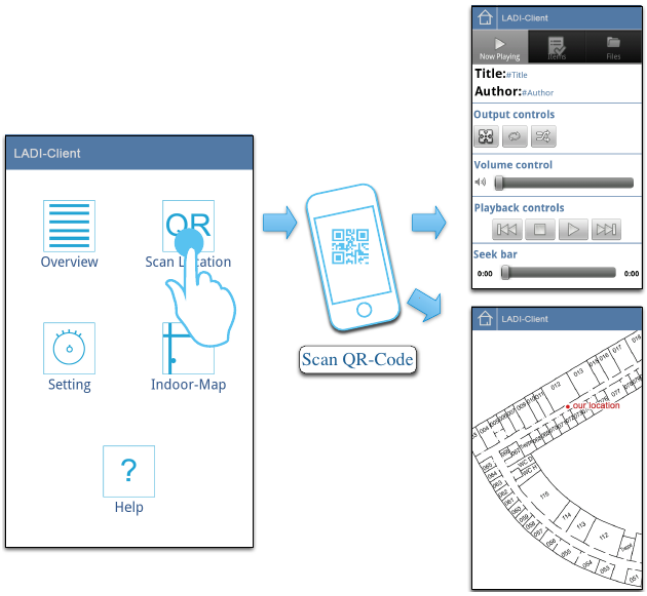
Requirements

1. Presentation control
   - playback of time-based multimedia objects, such as video or audio files
   - presentation of slide decks
2. Location-centric instead of network-centric approaches, in particular should user devices not need to be on the same network segment as the device controlled
3. Design of communication and control protocols extending existing protocols to limit changes to network setups
   - Works through Firewalls
4. Access to cloud-based media repositories with semantically rich representations of media as well as media local to the media renderer
5. Levels of control ranging from automatic to user-initiated

LADI in context

- LADI – Location-Aware Device Integration
- Cross-Device Integration (XDI)
- Utilises
  - Pads,
  - Tabs, and
  - Boards
- Location-centric, not network-centric
- Storage (for example) in “the cloud”
- Challenges:
  - Indoor-localisation
  - Media access
  - Access control
  - Device capabilities

Example: LADI



Example: LADI in use

4.6 AmbieSense

Context Awareness

- A systems that wish to exhibit context-awareness must be more than a simple reactive systems.
- Use of words *aware* and *awareness* imply a consciousness about the subject matter.
- Context awareness is not only a stimuli-response based reaction to context and contextual changes.
- It is essential that the system is able to 'understand' or at least asses situations.

A model at the knowledge level is necessary.

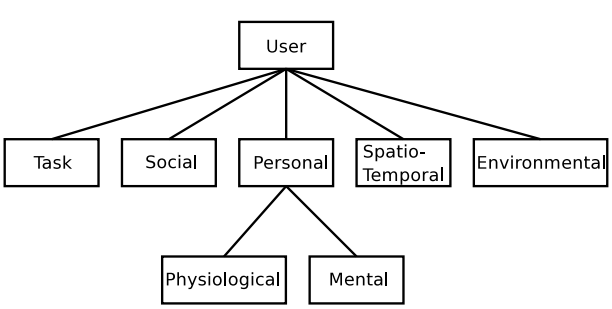
Kick-start

- An *a priory* description might or might not be desirable
- Even if desirable, it is still not feasible to wait for a system to develop context-awareness.
- A knowledge-level model can give the system a kick-start.
- The system has to be able to learn further.
- Such a system was developed in the AmbieSense project.
- But: **We are in need of a methodology for knowledge-level modelling of context awareness.**
- Our proposal: Activity Theory.

Motivation

- A pragmatic definition of context allows application developers to efficiently rule out information that is not context in their particular application domain.
- At design time, developers can ask: 'Is this information relevant for adapting our services and information?'
- If the answer is no, the information is discarded as not being context, and excluded from the context model.
- Open context model that only defines the taxonomic structure in the design phase.
- Our model is structured around a taxonomy inherited from the context-aware tradition.

Context Model

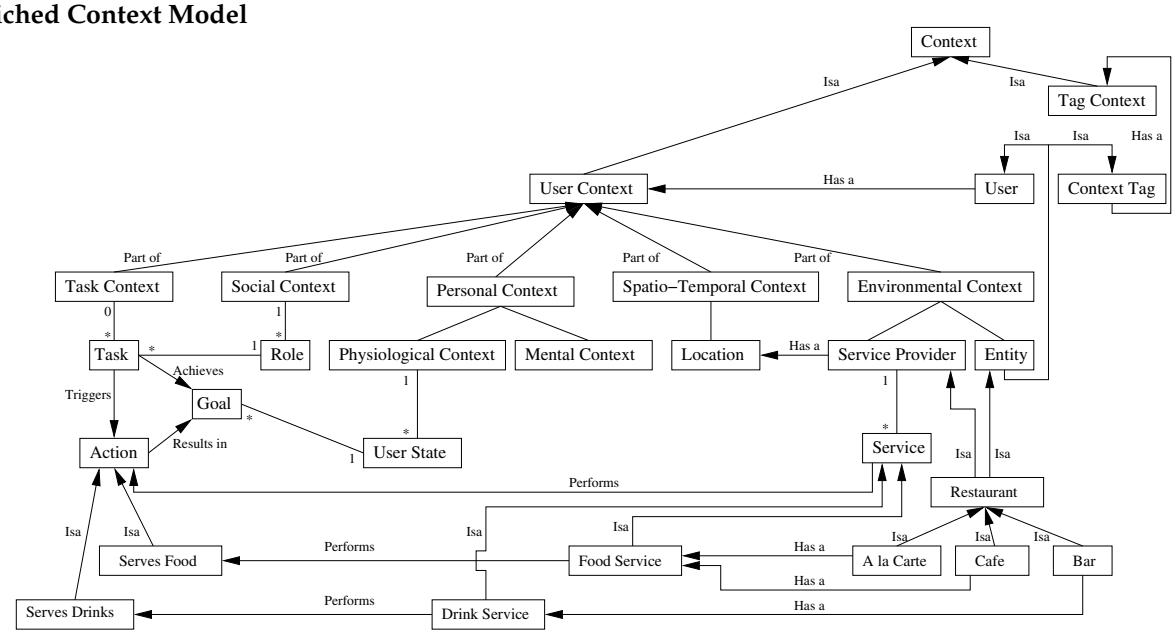


User context in AmbieSense

Parts of the AmbieSense Context Model

1. **Environmental context:** Captures the users surroundings, such as things, services, light, people, and information accessed by the user.
2. **Personal context:** Mental and physical information about the user, such as mood, expertise, disabilities and weight.
3. **Social context:** Social aspects of the user, such as information about friends, relatives and colleagues.
4. **Task context:** Describe what the user is doing, it can describe the user's goals, tasks, activities, etc.
5. **Spatio-temporal context:** This type of context is concerned with attributes like: time, location and movement. The different aspects of the contexts are attribute-value tuples that are associated with the appropriate contexts.

Enriched Context Model



Enriched context part of knowledge model

Activity Theory

- Activity Theory is a descriptive tool to help understand the unity of consciousness and activity.
- Its focus lies on individual and collective work practise.
- In human activities, a *subject* uses some *mediating artefacts* on *objects* to realize an anticipated outcome.
- One of its strengths is the ability to identify the role of material artefacts in the work process.
- Human activity is mediated by tools, language, etc. The artefacts as such are not the object of our activities, but appear already as socio-cultural entities.

Mapping Relations

Basic aspects of an activity and their relation to a taxonomy of contextual knowledge

CHAT aspect	**Category**
Subject	Personal Context
Object	Task Context
Community	Spatio-Temporal Context
Mediating Artefact	Environmental Context
Mediating Rules	Task Context
Mediating Division of Labour	Social Context

We do not think that a strict one to one mapping exists or is desirable at all.

Motivation

- Investigate how context-aware applications can assist clinical workers in a health care environment.
- A systems that wish to exhibit context-awareness must be more than a simple reactive systems.
- Awareness implies a consciousness about context, and not only a stimuli-response based reaction to context and contextual changes.
- Necessary to develop an understanding of what constitutes situations and how such information can be utilised to build better applications for health care.

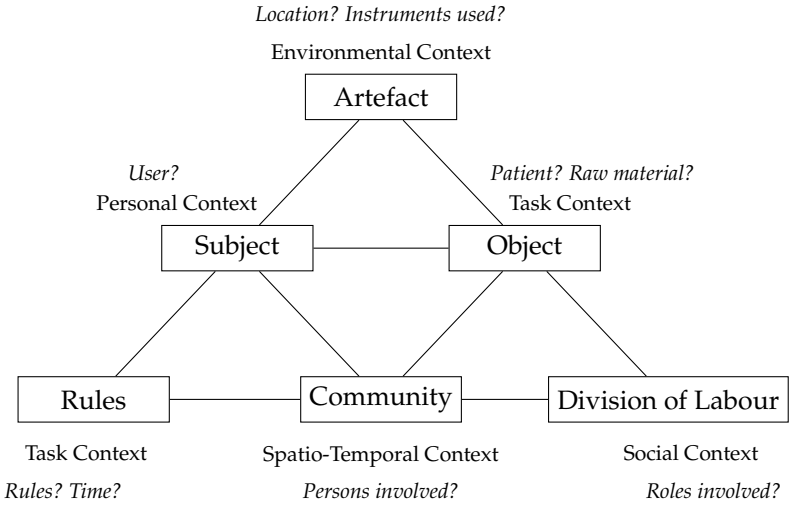
We believe context-awareness is a key element in bridging the gap between health care industry as early adaptors of cutting edge medical technology, compared with the slow adoption of information solutions.

Approach

- Collect information about real situations occurring at a hospital ward; such as *initial assessment*, *visit* and *pre-operation*.
- Model a sub-set of these situations a cases in the case-base and implement the correspoding information services
- Another sub-set of the observations was used to 'blind-test' the systems ability to assess situations and react.

A medical student was doing observations in several wards.

Mapping Revisited



Empirical Study

- Activity/Trigger
- Rules Involved
- Place and Time
- Person (ID)
- Role
- Other Persons Involved
- Patient History
- Reason for Treatment
- Information Sources
- Objective
- Result

Data Gathering

- In the first step, the data is recorded using a mixture of free text and attribute value tupels with a restricted range of values.
- CHAT was used to determine the 'right questions' .

Obervasjonsskjema				Dag		Afdeling									
Aktivitet/trigger	Regel	Sted	Stillings ID	Rolle	Tilstede	Rolle	Patient ID	Tidligere sygehistorie	Indlæggelsesgrund	Tid	Kilde	I/U	Info	Hensigt	Resultat
RTG møde	Fast tid man-fre	RD1	AL1	PA	ML1	PA	P16	Hjerneslag med mindre seqeler Bypassoperert grunnet angina med funn på angiografi Hypothyreose Depresjon	Vektap på 5kg siste mnd, smerter i høyre del av magen, nedsatt appetitt, utvikling av gulsot Utredning på hva gulsoten kommer av og utelukke kreft som årsak	7:50	COL	I	FINDEX	Finne årsak til obstruksjonene i galleveiene på CT abdomen Stein eller svulst?	Finner svulst i bukspyttkjertelen s trykker på gallegan og stenger disse Denne er avgrense Bekrefter kreftmist Vurdere operasjon
	Fast sted				TL1	PA									
	Faste stillinger				AL1	PA									
	Faste roller, ID, eller turnus				AL2	PA									
					AL3	PA									
					OL1	AD									
					OL2	AD									
					OL3	POL									
					OL4	POL									
					OL5	PU									
					OL6	PU									
										7:59					Resten av rtg demonstrasjon avl grunnet dataproble

Knowledge Modelling

- The data was post-processed with respect to our knowledge model.
- CHAT was used to help mapping the data to the AmbieSense model.
- Example:
  - **Rules** → **Standard procedure:** Lab test to count white blood cells is done when a bacterial infection is suspected → **Task Context**.
  - **Division of Labor** → **Role:** Certain roles have to be present at daily RTG meetings → **Social Context**.
  - **Tool** → **Instruments used:** Special Monitors are used for watching X-Rays → **Environmental Context**.

Two-fold Use of Activity Theory

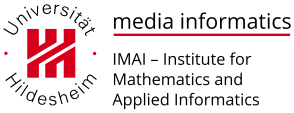
- Knowledge engineering with "Activity-Theoretic Goggles": we try to understand the basic properties of the workplace using CHAT
- Two-fold use of the theory
  - Building the model: Building a knowledge model which can capture the basic concepts of AT
    - General knowledge about human work processes together with "best practice" knowledge is used to identify components of the context model
  - Populating the model: Using empirical evidence to fill the model
    - Results from Activity-Theoretic field studies can be used to generate an initial knowledge model (that can be enhanced by online learning)

Usage Scenario

- Let us assume the system has recognised a ward round
  - Includes discussing medical conditions and treatments with several patients
- The system will try to prepare all the relevant information to be presented to the user
- The system asks other available artefacts for test results on the user:
  - The medical images database offers a MR image
  - The patient record offers a textual description of the MRI
- Because of limitations of handheld devices, the system is not able to display high resolution MR images
- The system will reject the medical image database and only query the electronic patient record database

4.7 Partners

Partners



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