Universidade do Minho
Departamento de Informática

Sensorização e Ambiente

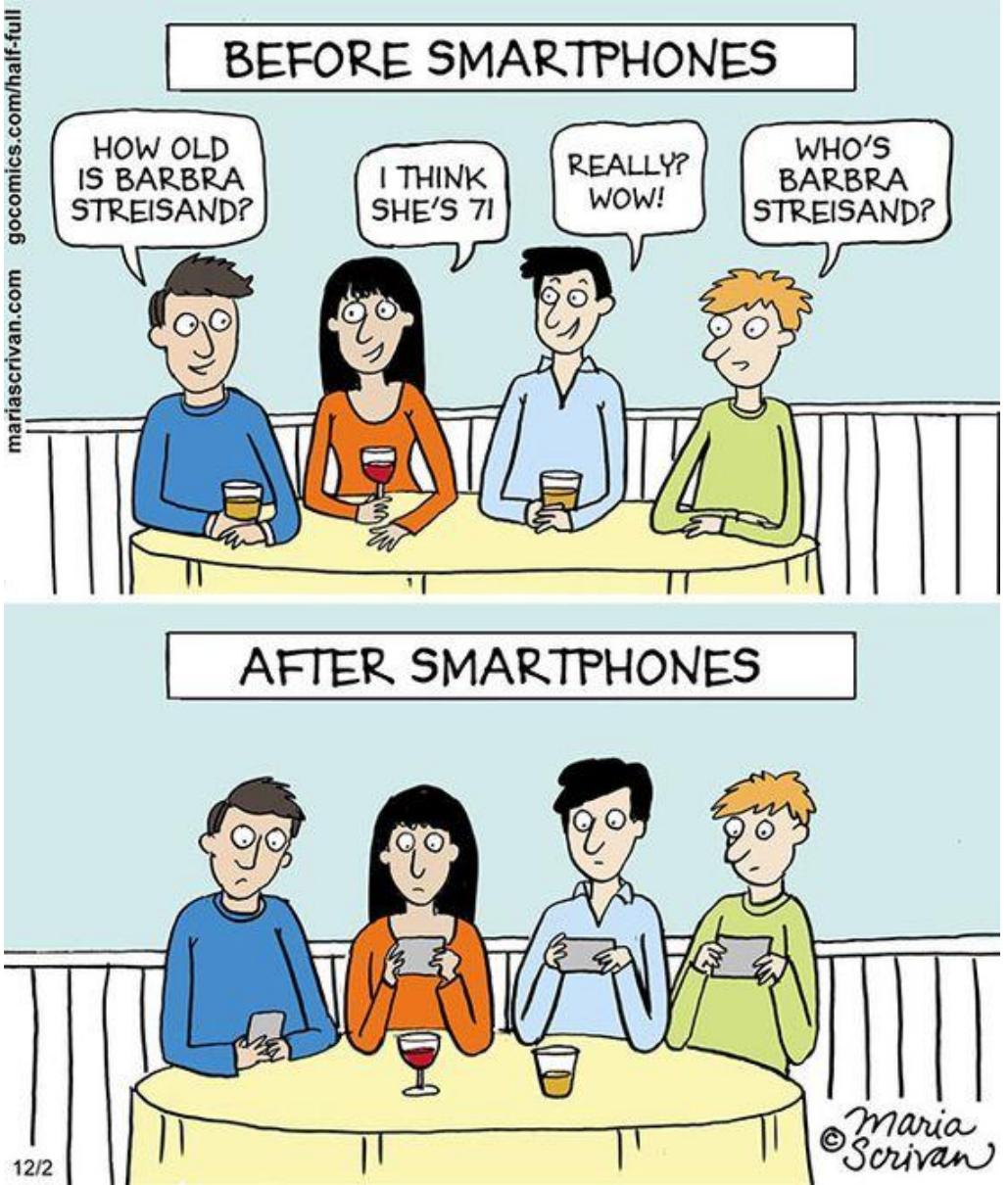
Oportunidades, Desafios e Ameaças

SA @ Perfil SI, MEI
2º sem, 2024/2025

Agenda

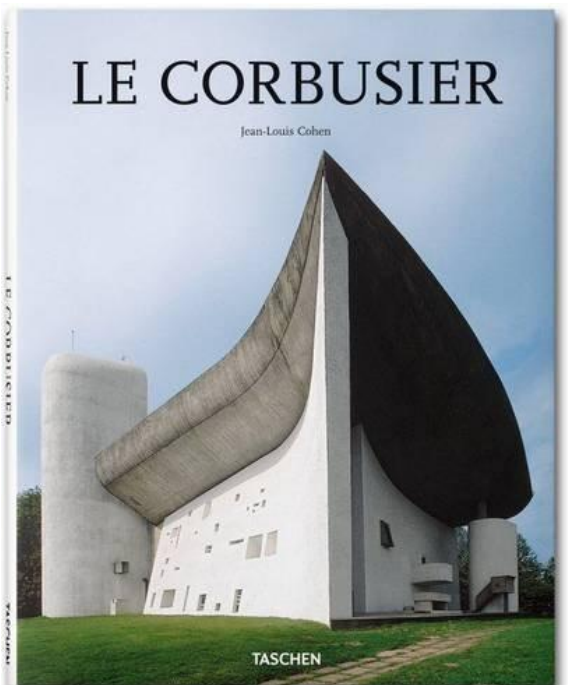
- **Motivation**
- Vision
- Projects and Trends
- Projects @ UMinho
- Development of applications
- Final considerations
- New paths

Technology is here!



Live inside machines

- Le Corbusier (architect 1887-1963)
  - "A house is a machine for living in"



- Vic Callaghan (UEssex 2000)
  - "A building is a robot we live inside"

Buildings as Intelligent Autonomous Systems: A Model for Integrating Personal and Building Agents

Vic Callaghan, Graham Clarke, Anthony Pounds-Cornish, Sue Sharples
University of Essex, Wivenhoe Park, Colchester, CO4 3SQ

1.0 Abstract

We describe a new application domain for intelligent autonomous systems – intelligent buildings. We show how a building can be regarded as a machine and how behaviour-based principles first proposed by Brooks for mobile-robot control can be applied to enable autonomous intelligent-building agents to adapt their control to suit the occupants. We present a novel approach to the implementation of Intelligent Buildings

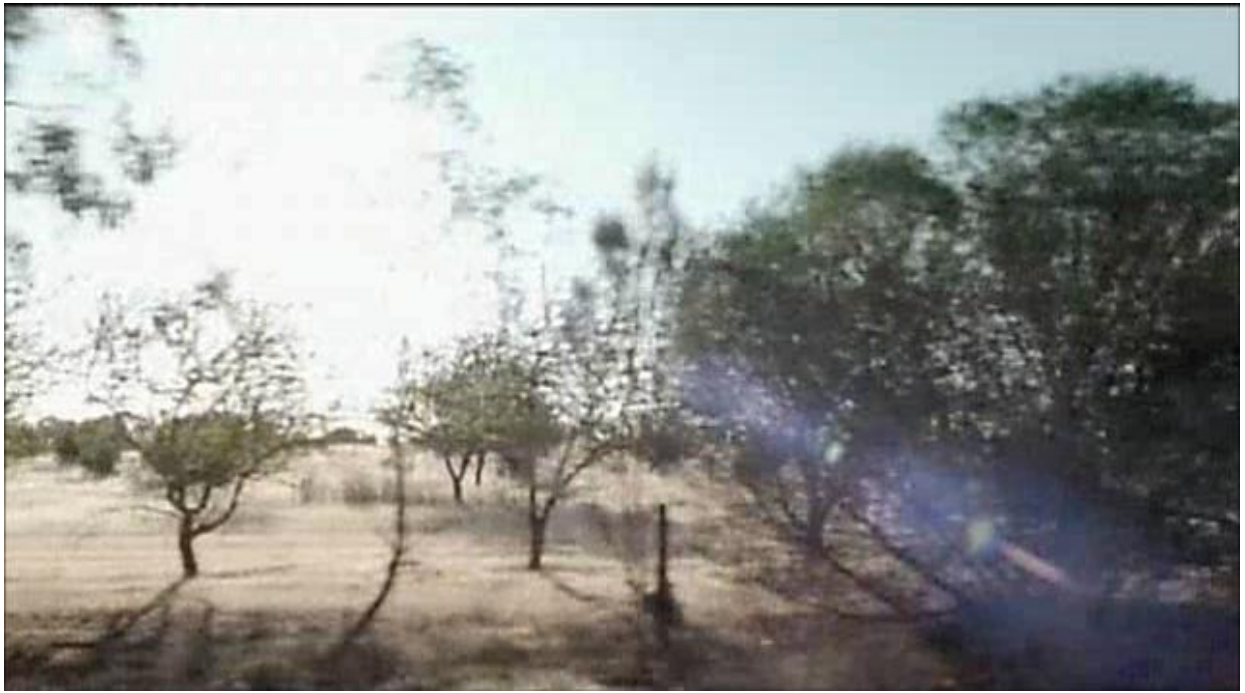
Presented at the 6th International Conference on Intelligent Autonomous Systems, Venice July 25-27 2000

techniques difficult to apply. Both practical and market-driven factors require building control systems to have a small computational footprint. Hence in intelligent-buildings, centralised, traditional AI, with bulky planners and reasoning systems, becomes less attractive. Incorporating sophisticated control techniques into intelligent buildings presents a considerable design challenge. From the considerations above we suggest a modification to Le Corbusier's slogan so that in the future "*A building is a robot we live inside*".

A perspective about “new” living environments

- “*In the years ahead, further exciting innovations will unify the software, hardware and services in people’s lives, offering them even richer, more engaging and deeply connected experiences.*”

Bill Gates,
Outlines Vision for the Digital Lifestyle (2006)



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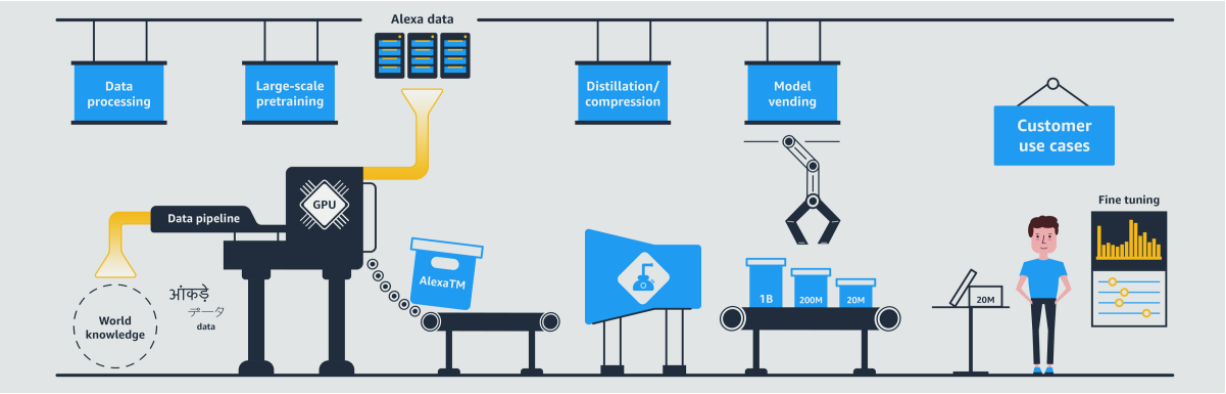
Ambient Intelligence

- The Ambient Intelligence (AmI) concept emerged in 2001 from ISTAG (IST Advisory Group of EC)

ISTAG (2001), Scenarios for Ambient Intelligence in 2010, European Commission Report

- AmI is a new way of approaching the surrounding environment where devices with computing power are scattered everywhere (**ubiquity**), eventually included in objects (**embedded systems**), allowing the human being to interact in the real world in an intelligent and discrete way (**pervasive computing**). These environments must be aware of people's needs (**context awareness**), with personalized requirements and predictive behaviors.



https://www.amazon.science/blog/ambient-intelligence-will-accelerate-advancements-in-general-ai

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Ambient Technology

ISTAG (2001), Scenarios for Ambient Intelligence in 2010, European Commission Report

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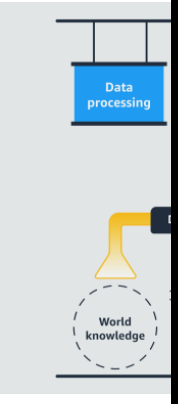


https://www.aboutamazon.com/news/devices/amazon-is-making-your-life-easier-through-ambient-intelligence

Ambient Intelligence

- "Ambient Intelligence envisions a world where people are surrounded by intelligent and intuitive interfaces embedded in the everyday objects around them. These interfaces recognize and respond to the presence and behavior of an individual in a personalized and relevant way."

  Pattie Maes (MIT)

- "These environments recognize and respond to the presence and behavior of an individual in a personalized and relevant way."

  Elisabetta Farella (University of Bologna)

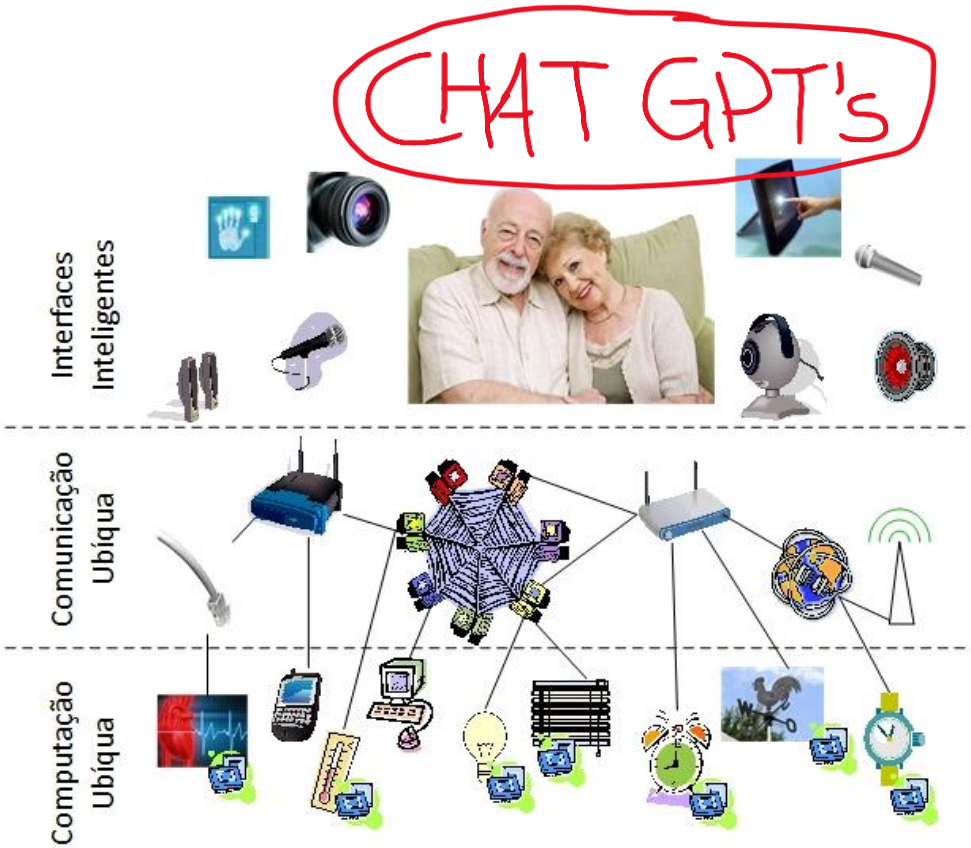
- "(...) **Ambient Computing** refers to a series of interconnected devices that work together to assist with or automate everyday tasks based on information gathered about your surroundings."

  Cameron Cashman (HP Tech)

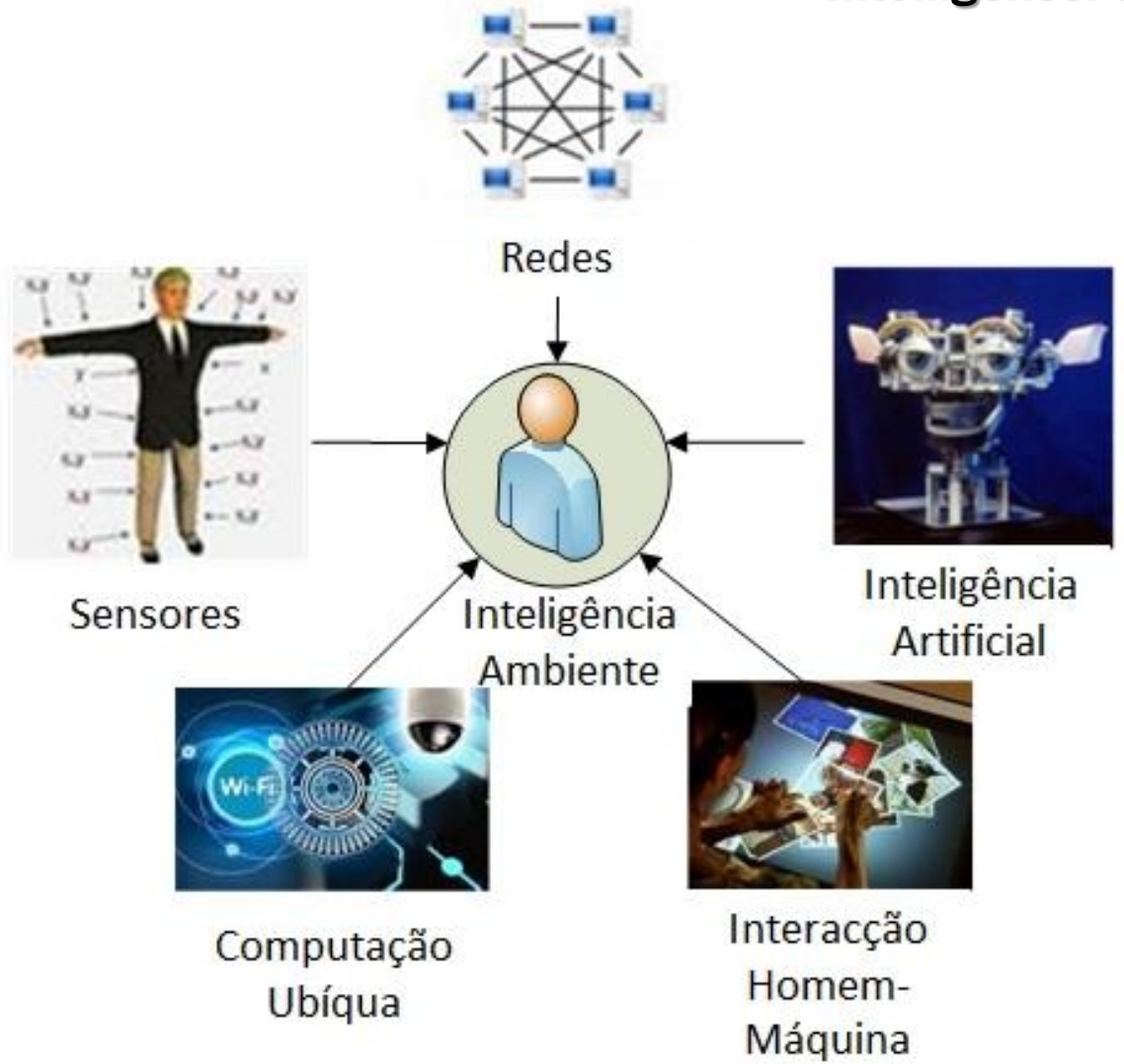
- "Environments that are sensitive and adaptable to the presence of people."

Support Technologies

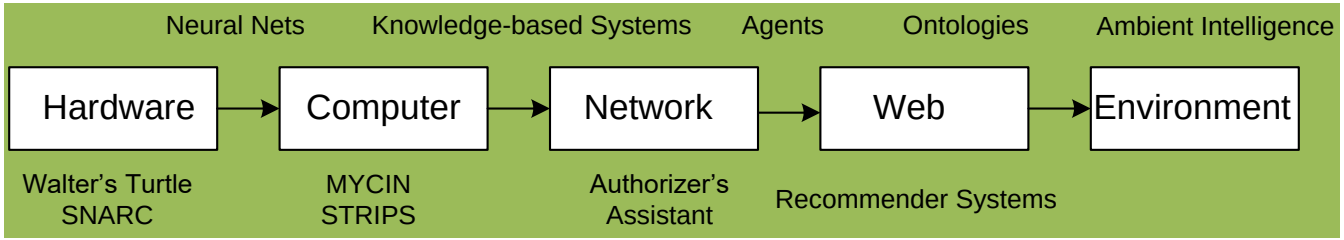
- Smart Interfaces
  - The interaction is carried out in a natural and personalized way (eg, voice, gestures).
- Ubiquitous communication
  - Enable communication between objects by means of networks
- Ubiquitous computing
  - Integration of microprocessors in everyday objects.



Intelligence: the missing element



- Environment: The Next Step!



Beginning of AI:
Neural models McCullock& Pitts, 40's
SNARC, Minsky & Edmonds, 50's

AI in real problems:
MYCIN on a computer, 70's
AUTHORIZER'S ASSISTANT, American Express, 80's
Agents and Recommendation Systems on the Web, 90's
Semantic Web, emerges in the 21st century

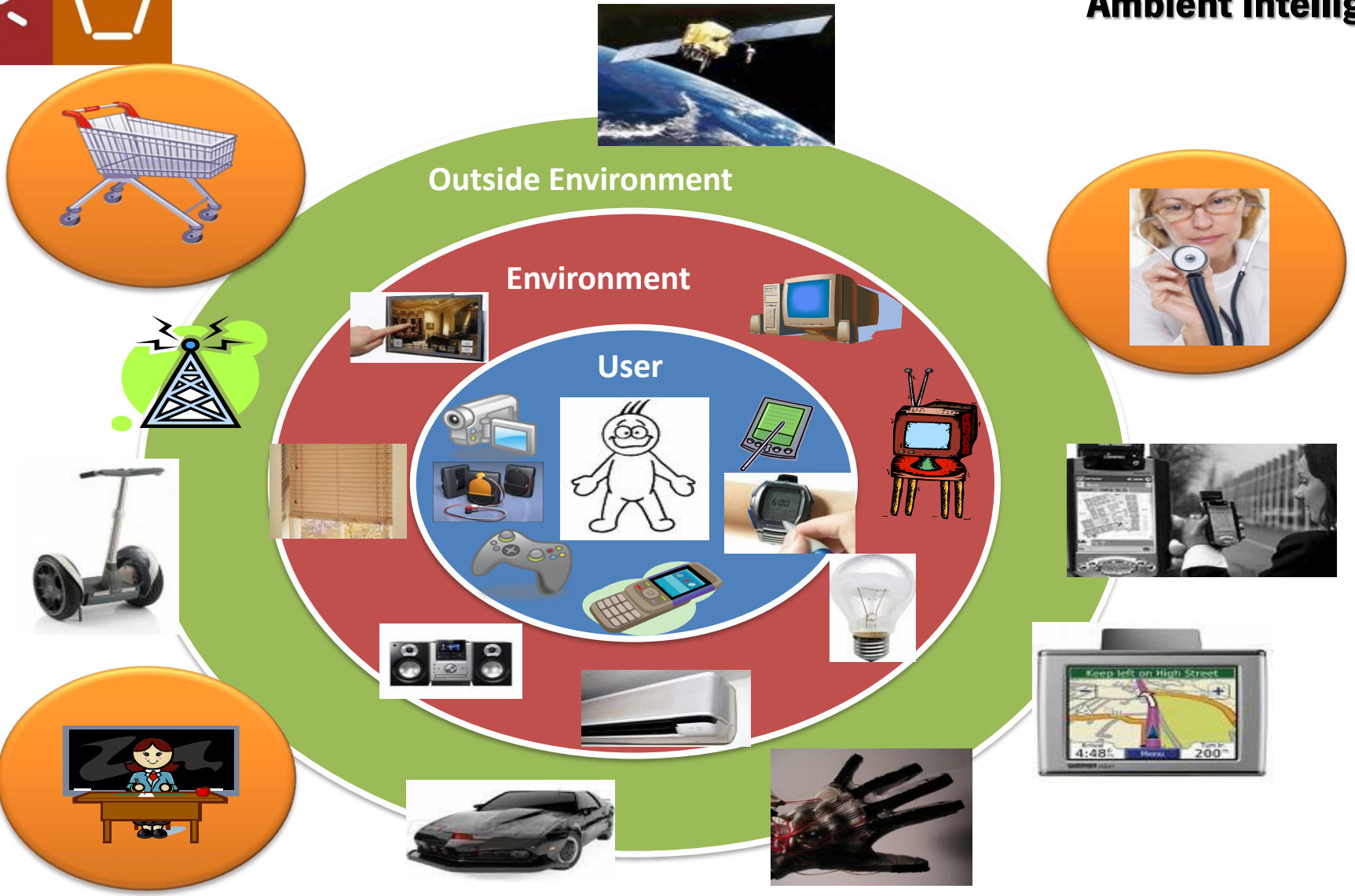
Ambient Intelligence

Artificial Intelligence

Ambient Intelligence

Ambient Assisted Living

Ambient Intelligence



Ambient Assisted Living

- Environments that monitor and assist people in their natural environment;
- Application of user-centered technology;
- The environment molds itself to the user;
- Applications:
  - Job;
  - House;
  - Medicine;
  - Teaching;
  - ...

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- Ambient Intelligence for the networked home environment
  - Philips Research (EU Project)

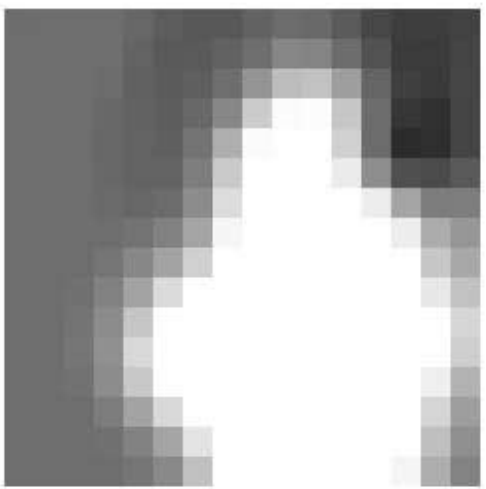
- The main purpose was to be able to take advantage of the possibility of networking, a strong bet on interoperability.

https://www.youtube.com/watch?v=wey94w-pNVI

Information Technology for Assisted Living at Home

- University of Berkeley
- Systems and devices that enable individuals with special needs to live in their home for longer, with greater security and confidence;
- The project explores how to integrate different technologies (zigbee, bluetooth, mobile devices), providing Assisted Living services.

- Smart Inactivity Monitor using Array Based Detectors
- University of Manchester
- Falls detection to be used in homes for the elderly.
  - The system uses a low-resolution infrared sensor to monitor a room.
  - When an individual who is in the ward falls down the system automatically activates a relief process by sending a message to a caregiver.



https://ieeexplore.ieee.org/document/1316817

HomMed Telemonitoring System

- Honeywell
- Remote monitoring platform of a patient's health status.
- The telemonitoring unit is placed in the user's home by collecting and transmitting data relating to the health status of the user to a central service that processes and presents this information to health care providers.

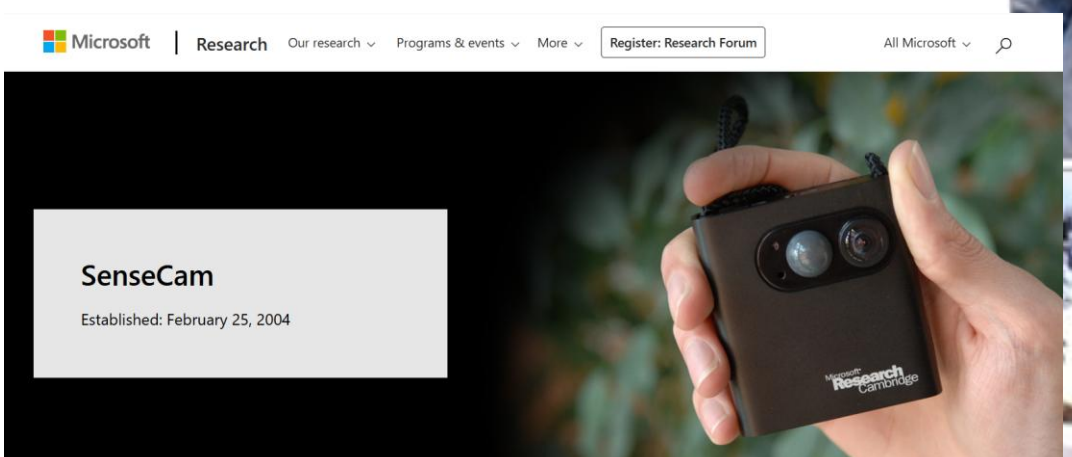
https://healthmastersinc.com/honeywell-hommed-health-monitoring-system

- Vision-based sensing for elderly and chronically ill people
- Imperial College
- System able to monitor the movement and activities of the elderly in their homes;
    - Through a pattern of daily activities, detect significant behavioral changes that show emergency situations.

https://www.doc.ic.ac.uk/vip/ubisense/home/home.html

Memory Assistants

- SenseCam (Microsoft)
  - Time Camera
  - For people with Alzheimer's



(microsoft.com/en-us/research/project/sensecam/introduction)

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Context Awareness

- Get the information in the right way, at the right time and place;

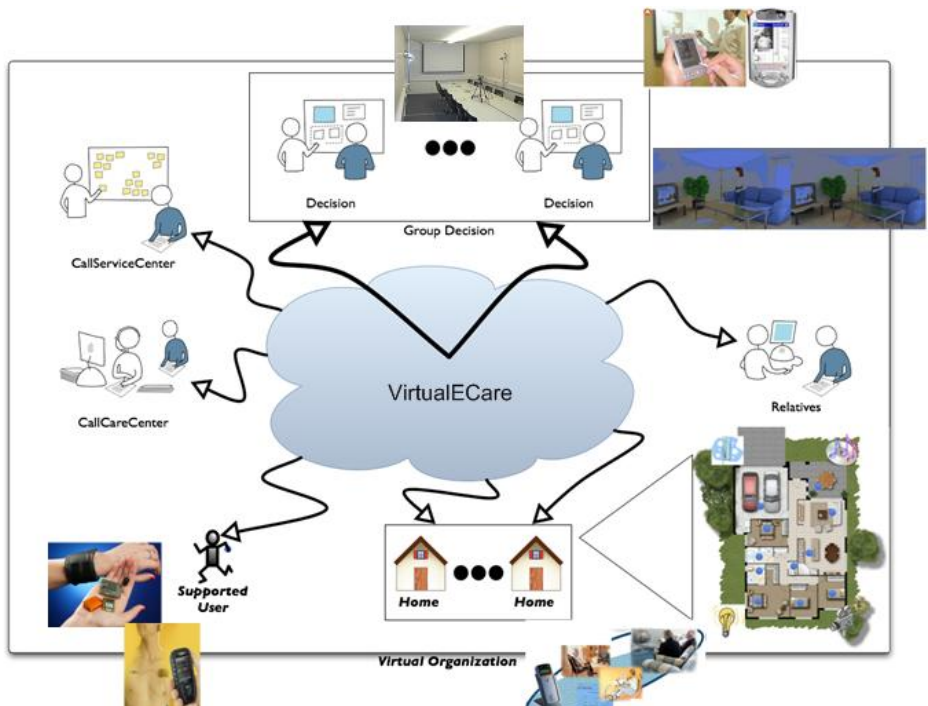
- **Any information** that may be used to characterize an entity (whether it is a person, place or object), **considered relevant to the interaction** between the user and an application, including the user and the application itself.

- Context is typically a location, identity, state (people, computing, and physical objects).

Research in Assisted Living Environments

- VirtualECare Project @ UMinho

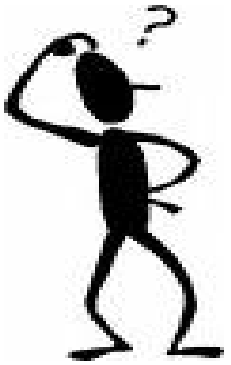
- Collaborative Networks as support for Assisted Environments



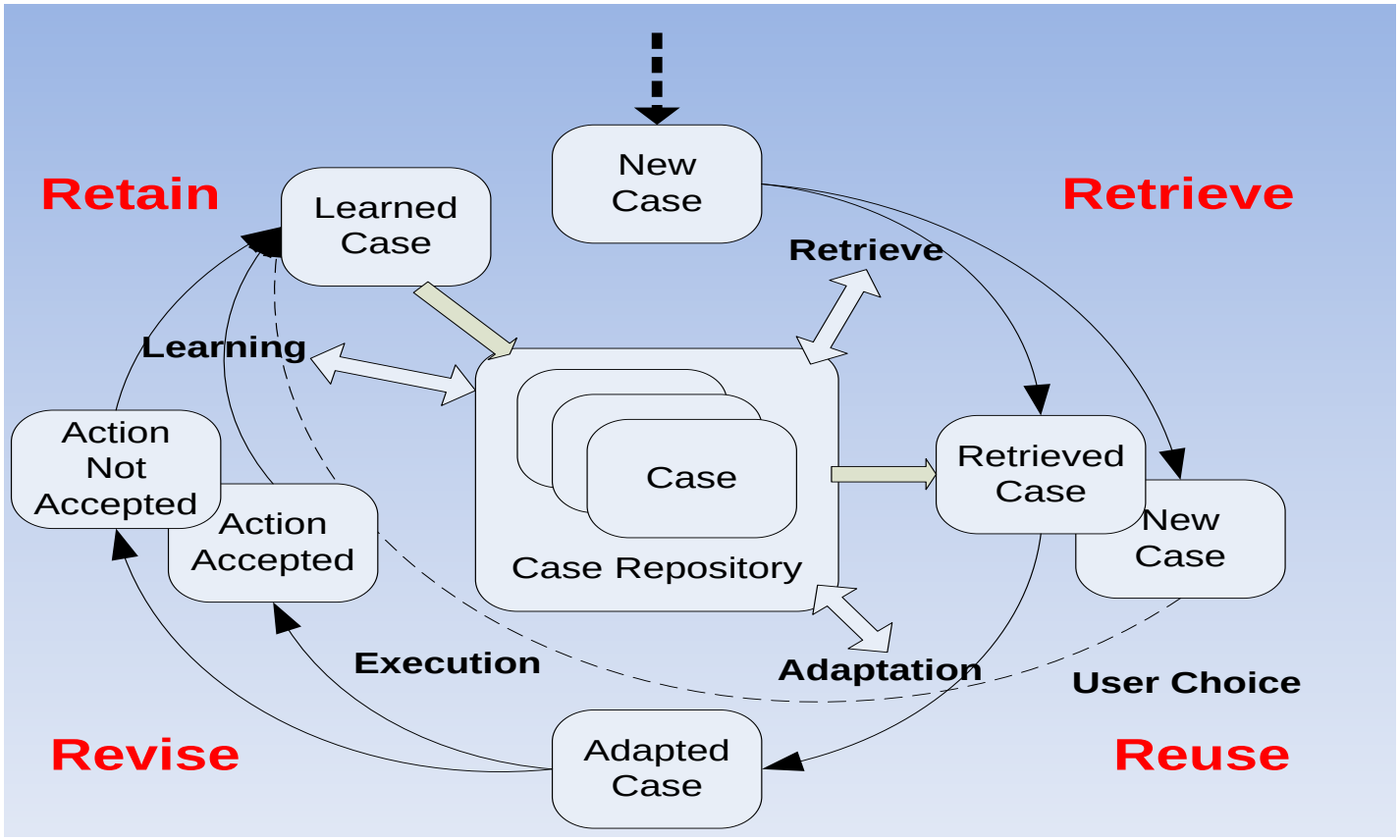
http://islab.di.uminho.pt/

Why Learn?

- Dealing with a fire alarm is easy:
  - Run away.
- Dealing with a slight rise in temperature is not so easy!
  - Open window?
  - Turn on air conditioning?
  - Move the blind?
- Profiles
  - Static
- Solution:
  - Learn from the user

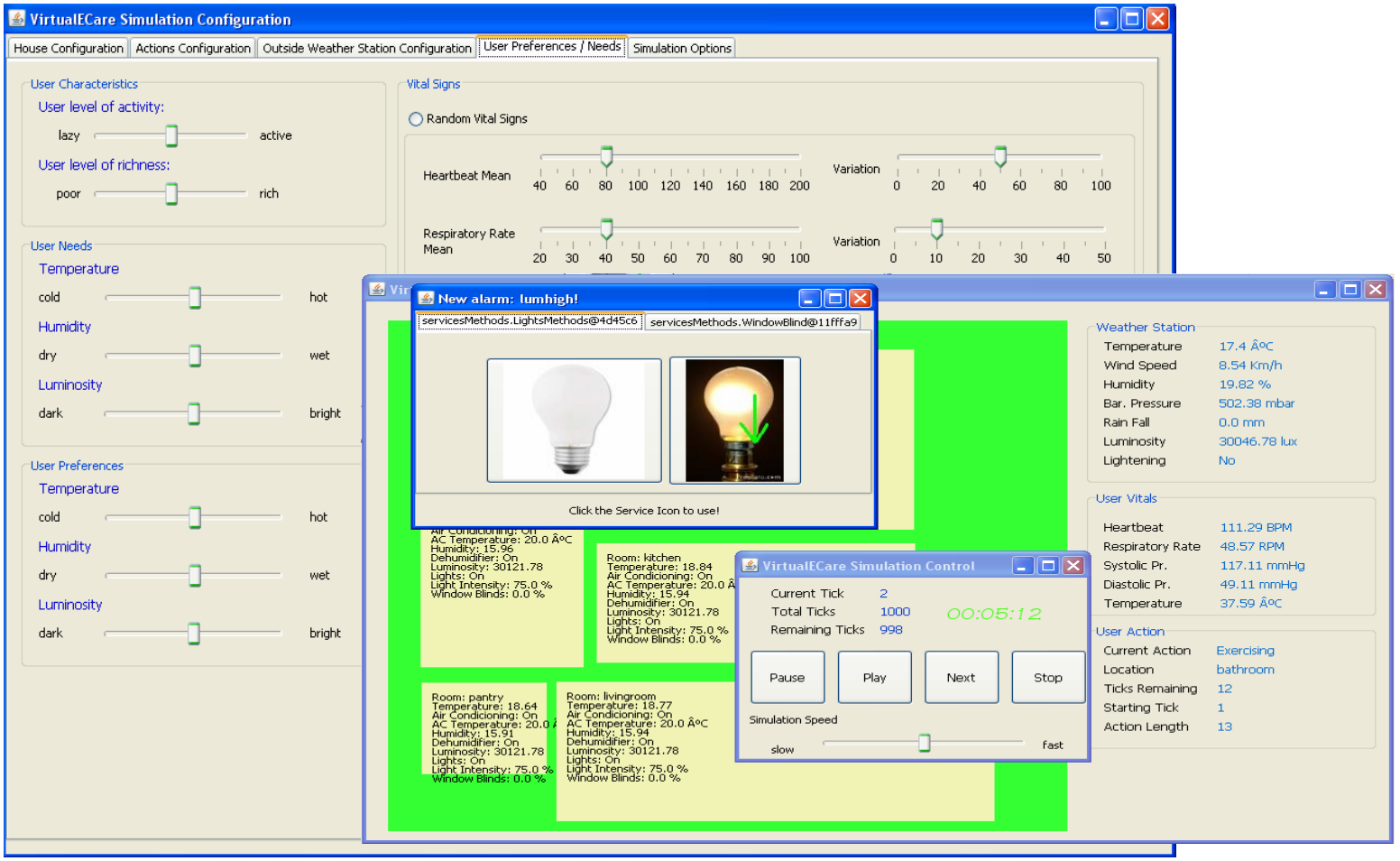


Case Based Reasoning



Agnar Aamodt & Eric Plaza (1994)

Simulation Environment



Research on Conflict Resolution

- From a paper-based society to a digital society

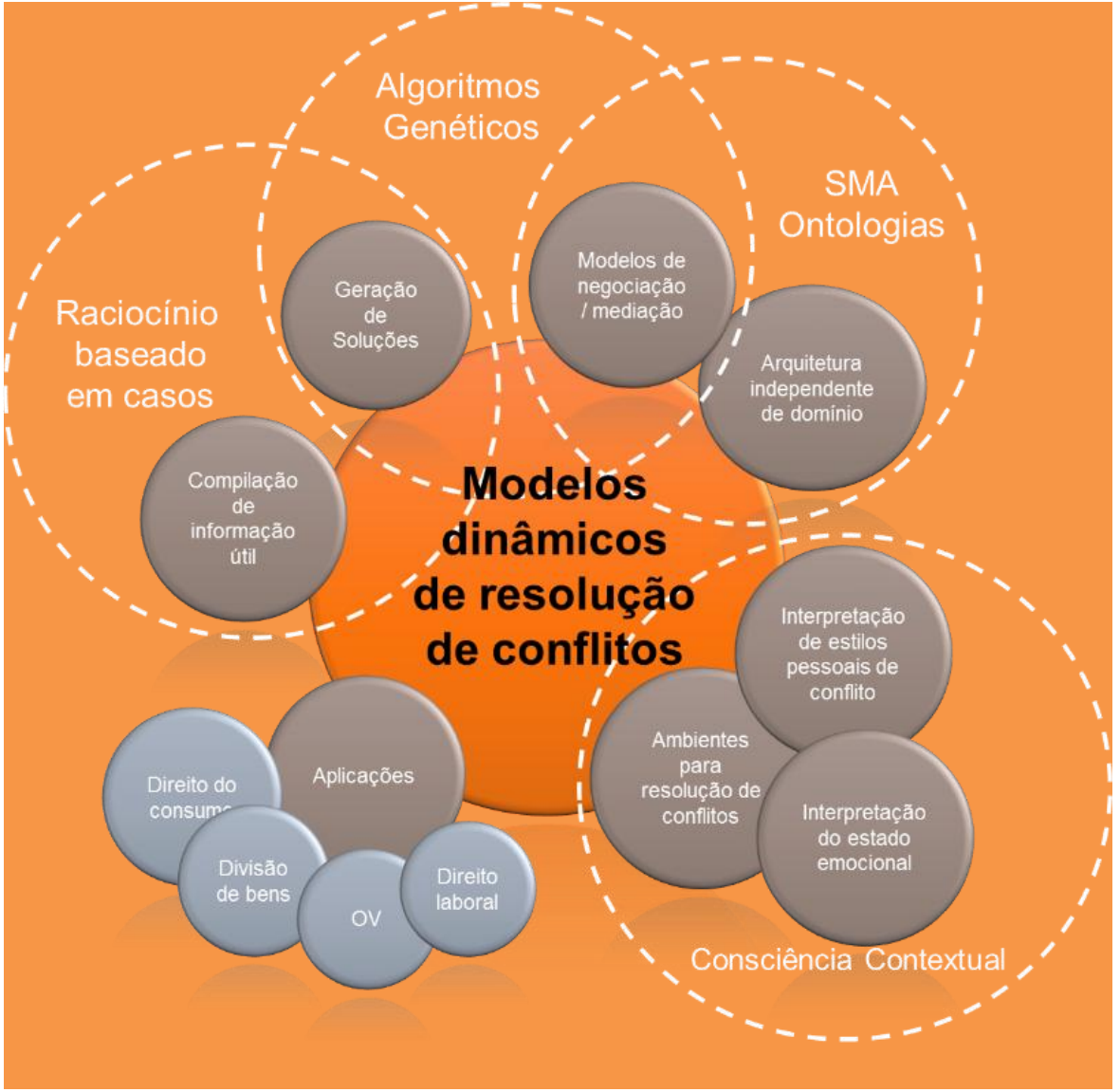
- With the growth of electronic contracting, we have a consequent increase in conflicts and the need for speedy resolution of conflicts;

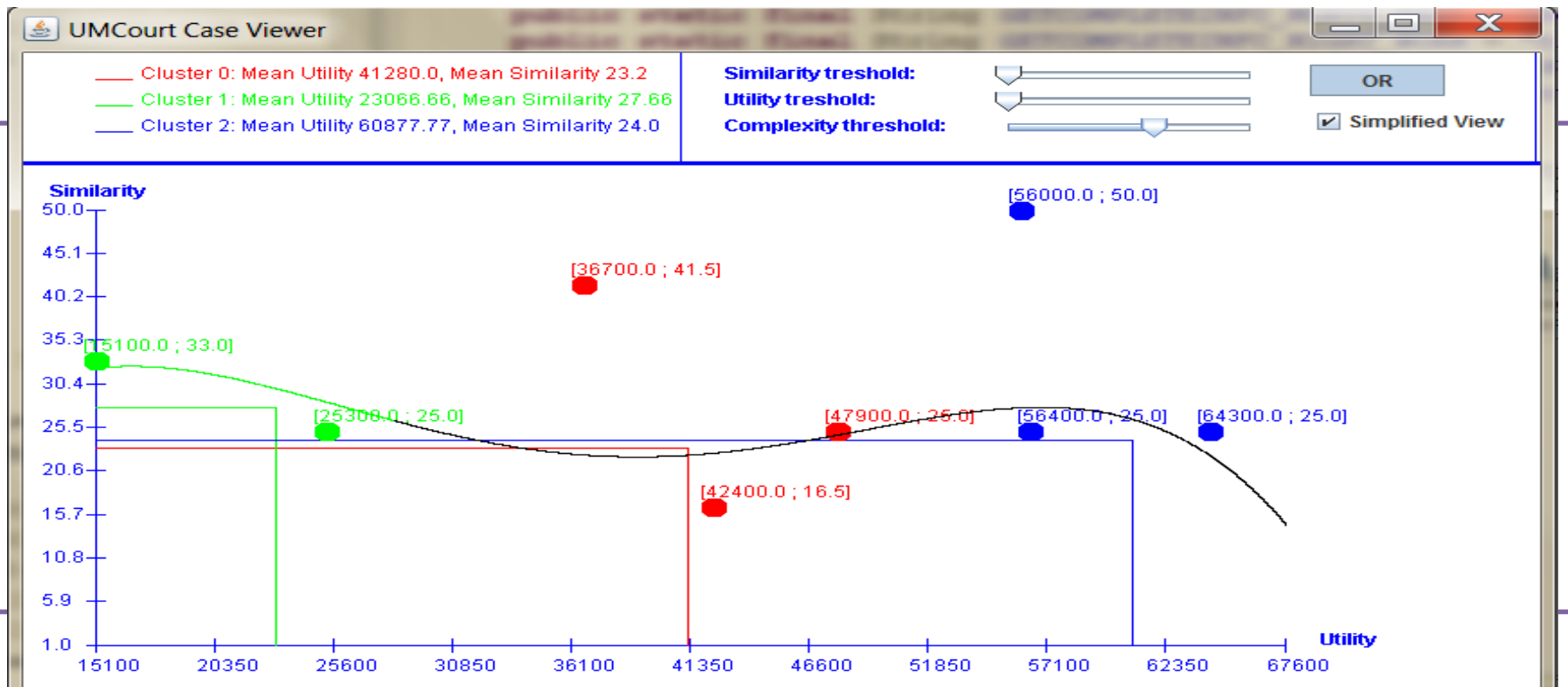
- Alternative Dispute Resolution
  - Negotiation
  - Mediation
  - Arbitration

- Online Conflict Resolution

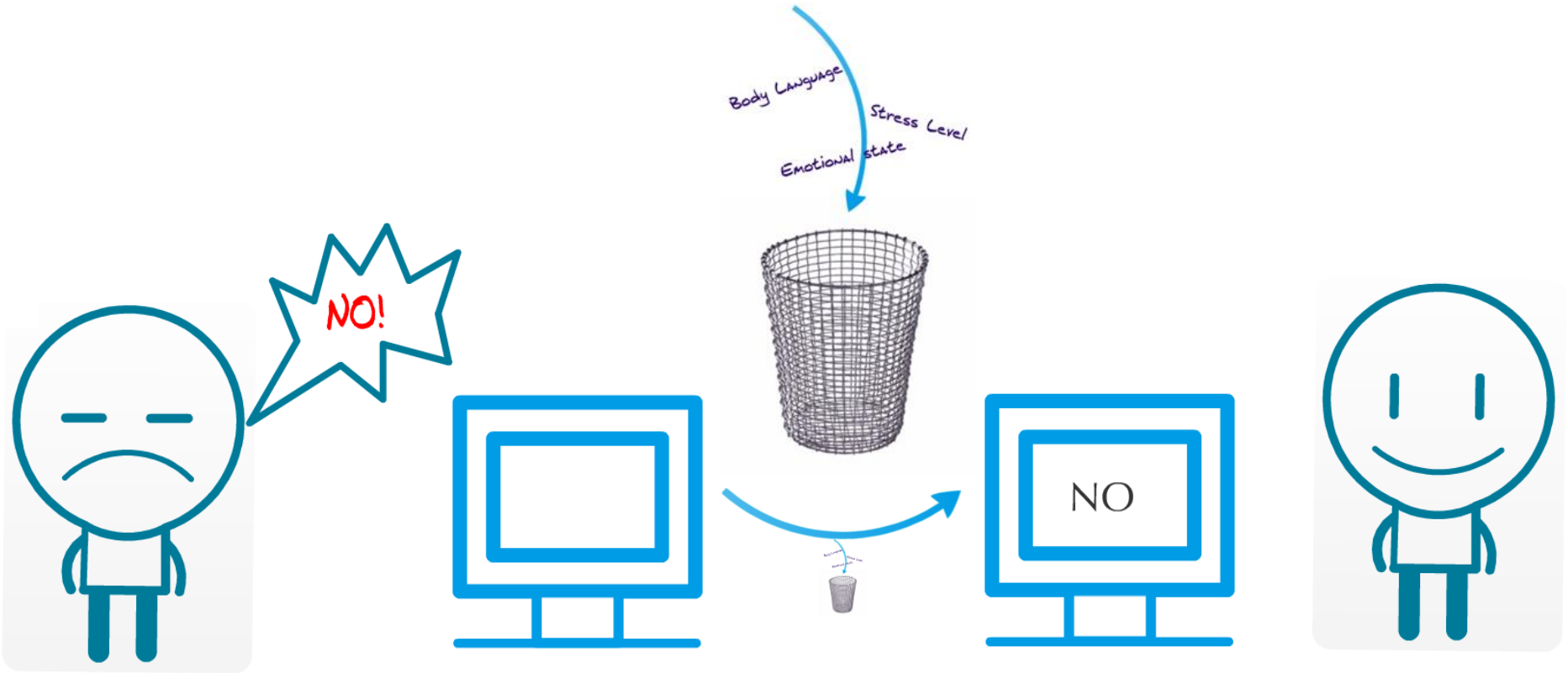
- TIARAC @ Universidade do Minho
- FCT project (Portuguese national funding agency for science, research and technology)
- Telematics and Artificial Intelligence in the Alternative Resolution of Conflicts.

http://islab.di.uminho.pt/tiarac/

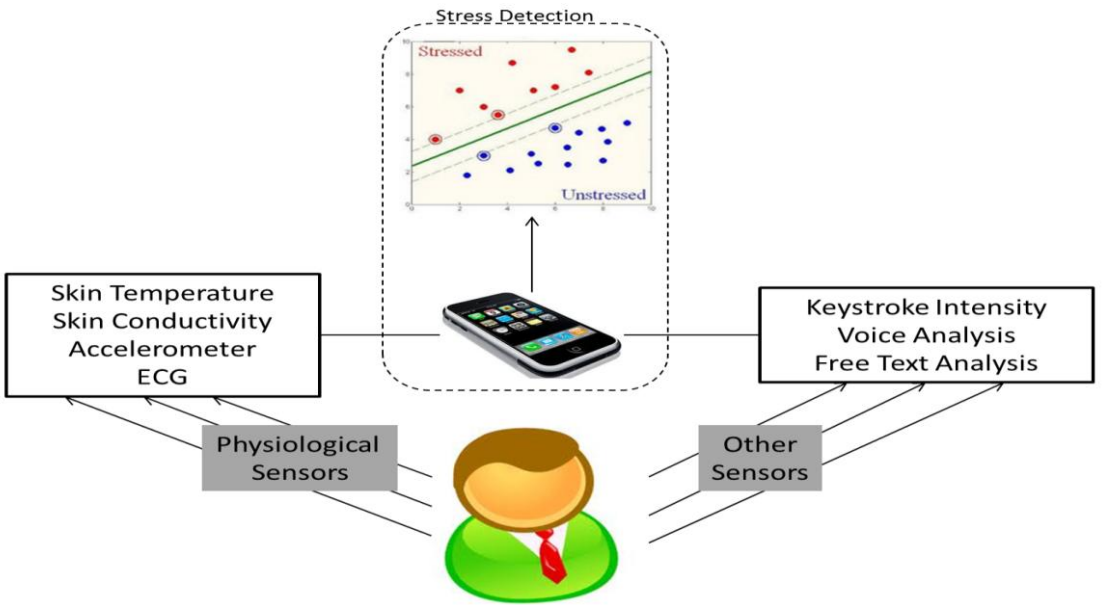

Algoritmos Genéticos
SMA Ontologias
Raciocínio baseado em casos
Geração de Soluções
Modelos de negociação / mediação
Arquitetura independente de domínio
Compilação de informação útil
Modelos dinâmicos de resolução de conflitos
Interpretação de estilos pessoais de conflito
Ambientes para resolução de conflitos
Interpretação do estado emocional
Aplicações
Direito do consum
Divisão de bens
OV
Direito laboral
Consciência Contextual

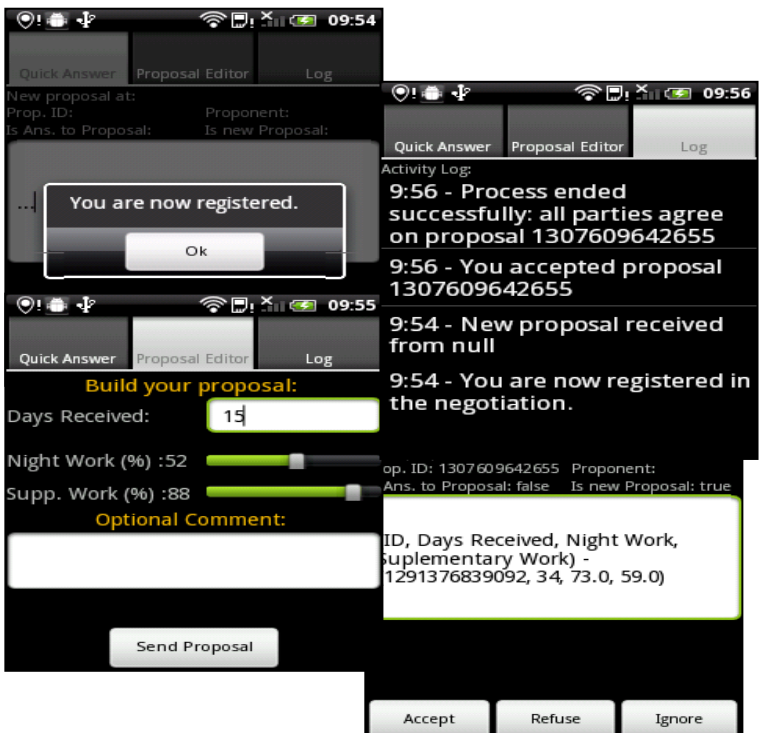

UMCourt Case Viewer
Cluster 0: Mean Utility 41280.0, Mean Similarity 23.2
Cluster 1: Mean Utility 23066.66, Mean Similarity 27.66
Cluster 2: Mean Utility 60877.77, Mean Similarity 24.0
Similarity treshold:
Utility treshold:
Complexity threshold:
OR
Simplified View
Similarity
50.0
45.1
40.2
35.3
30.4
25.5
20.6
15.7
10.8
5.9
1.0
[56000.0 ; 50.0]
[36700.0 ; 41.5]
[15100.0 ; 33.0]
[25300.0 ; 25.0]
[47900.0 ; 25.0]
[56400.0 ; 25.0]
[64300.0 ; 25.0]
[42400.0 ; 16.5]
Utility
15100
20350
25600
30850
36100
41350
46600
51850
57100
62350
67600

Transition



Stress Detection



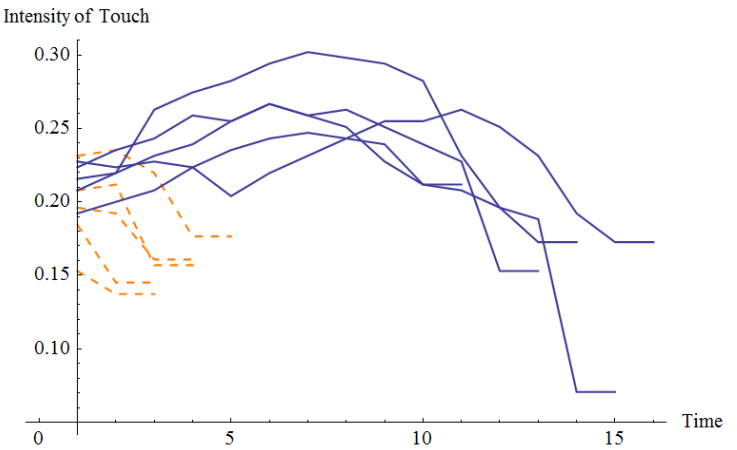


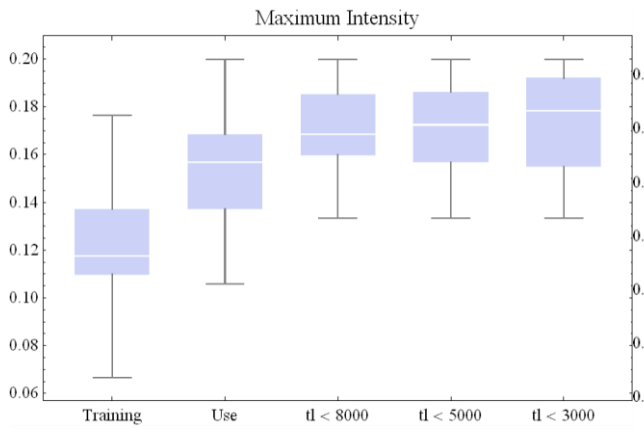
Stress Detection

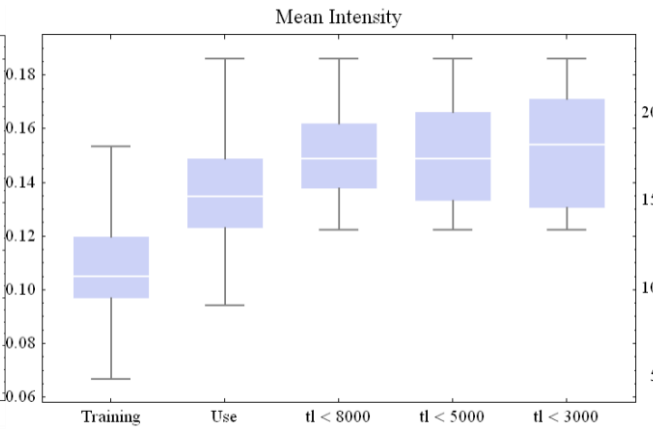
a)

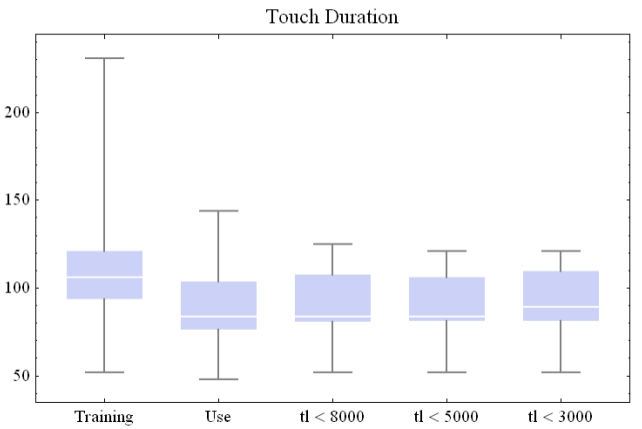
b)

c) M=18154 M=40985 M=18554 M=42696 M=26618

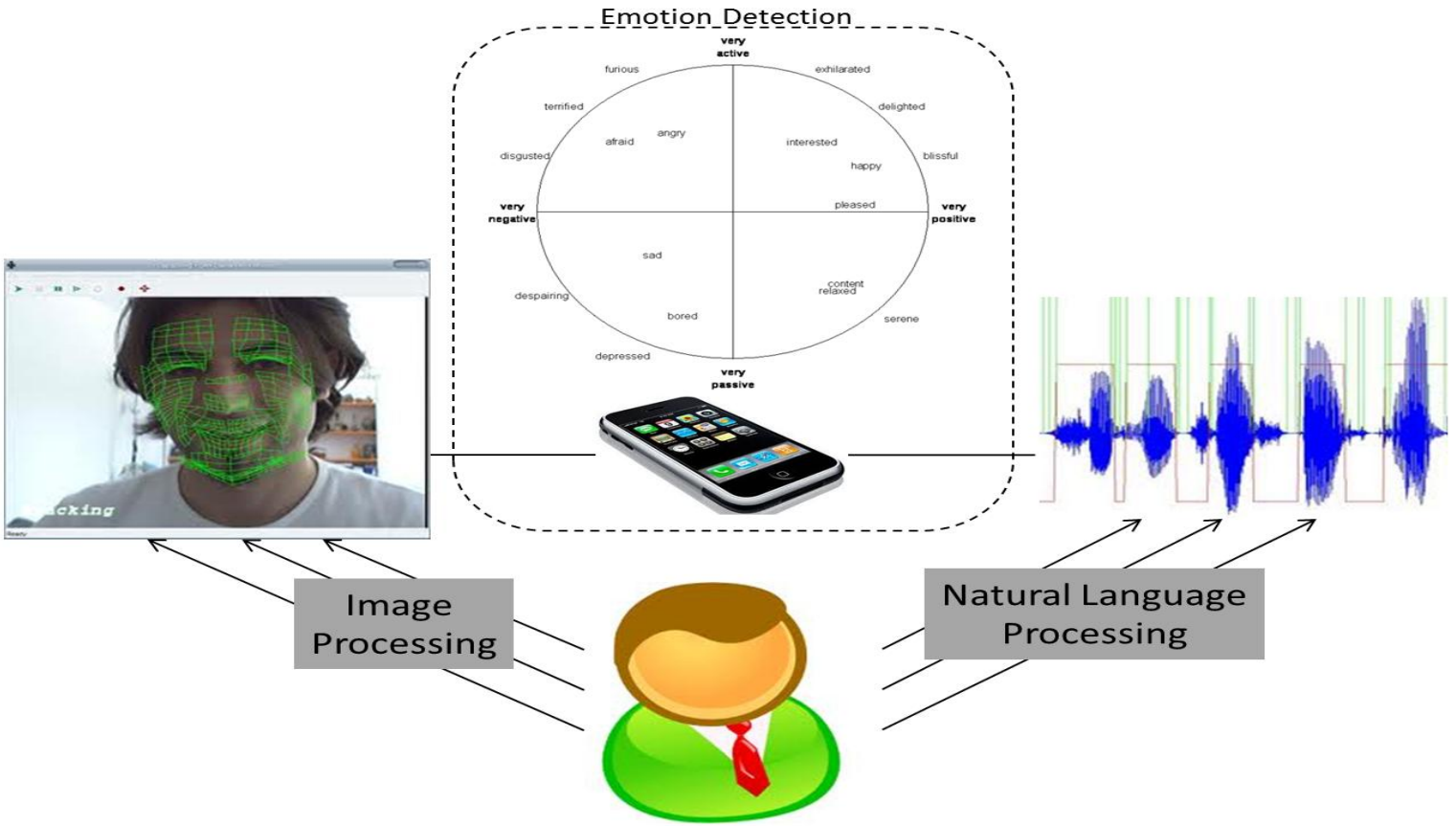




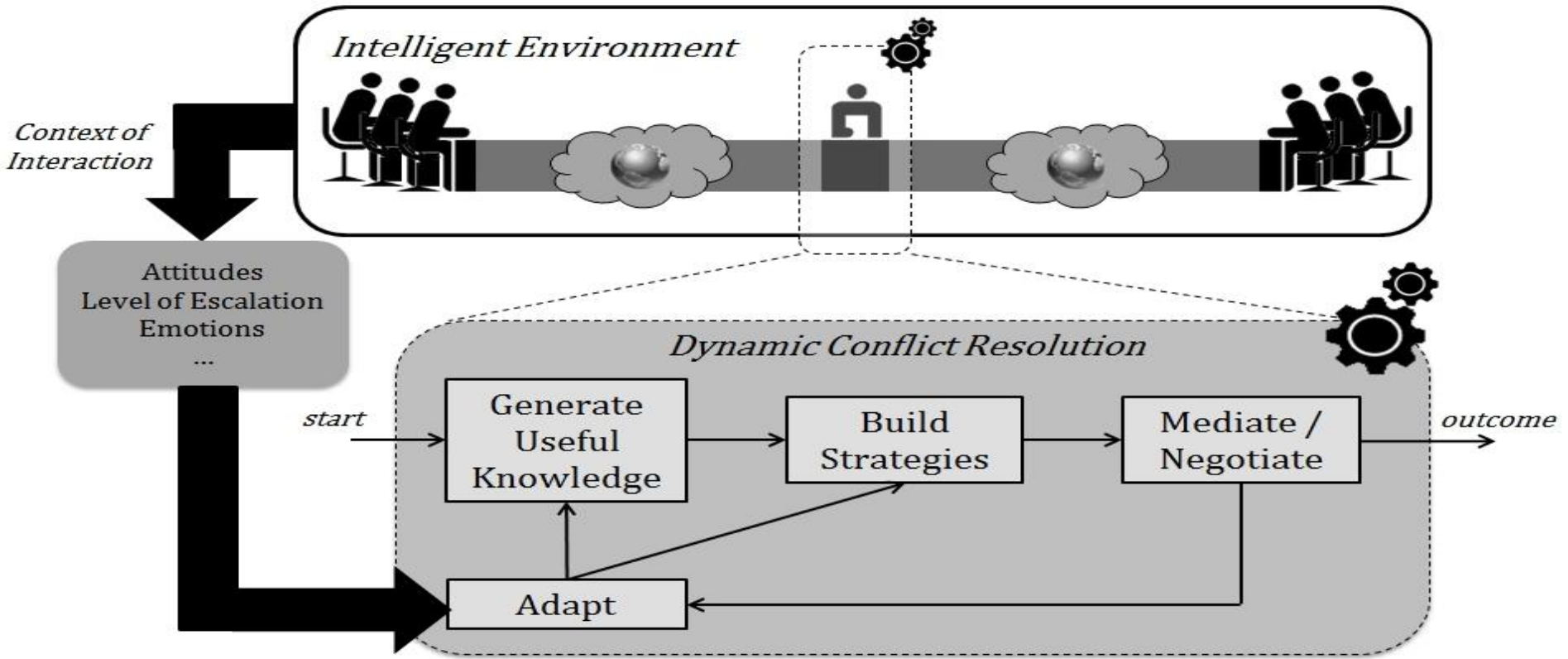




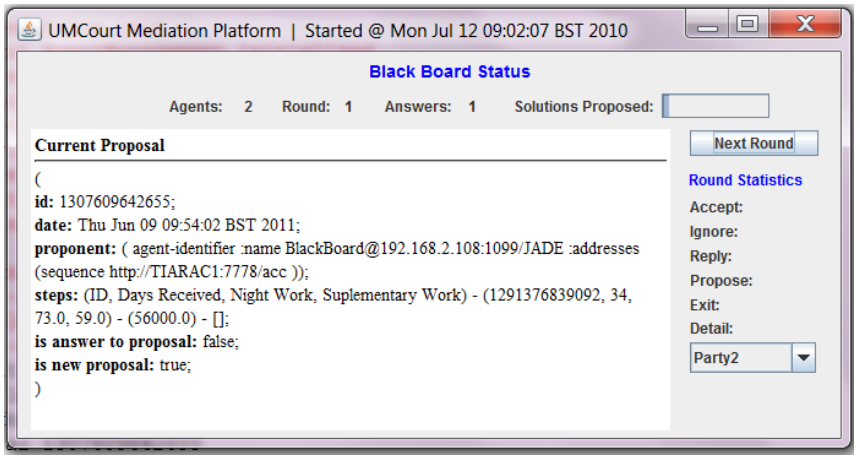
Emotion Detection

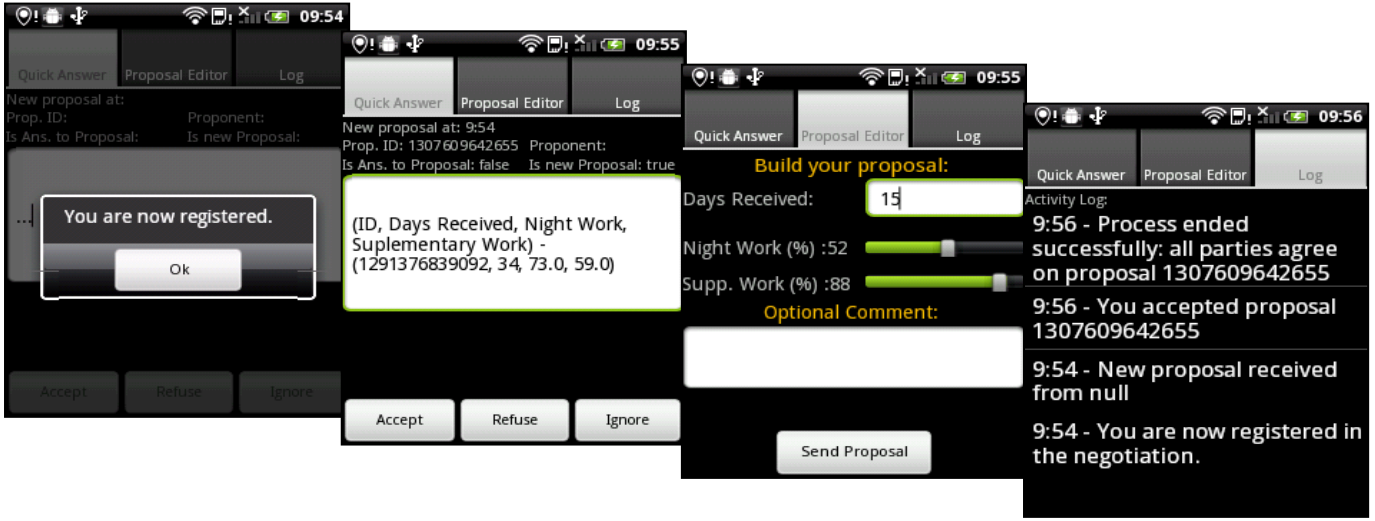


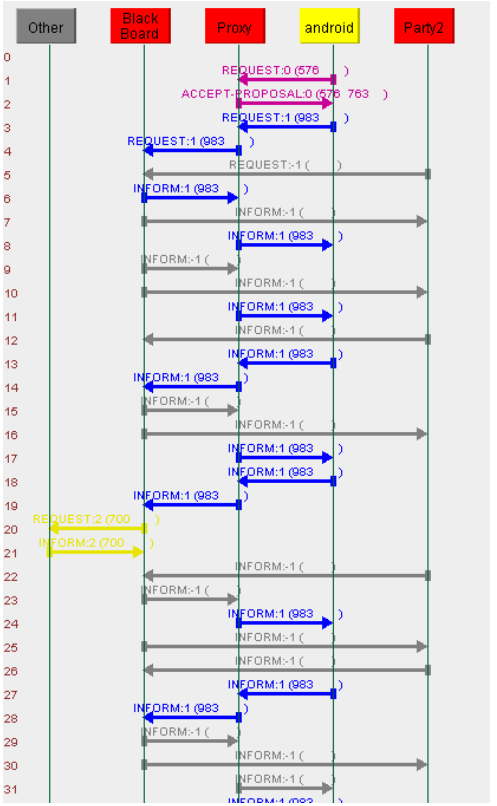
Dynamic Conflict Resolution



UMCourt
Negotiation / Mediation







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Best practices

- Our applications are called smart because (we expect) they can sense, anticipate and adapt themselves to the context, desires, and intentions of their users;

- However, the unpredictability of human behavior, the unanticipated circumstances of execution and a growing heterogeneity of future operational environments impose significant development challenges if these innovative applications are to gain wide acceptance in our daily life;

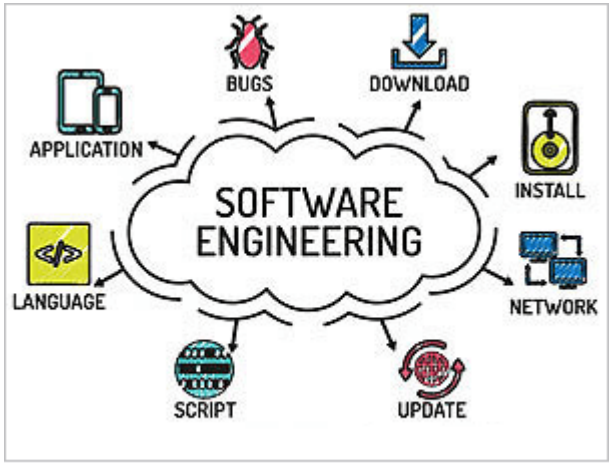
- Well-established software engineering methodologies is a fundamental prerequisite for delivering high quality and robust smart (even intelligent) software applications.

Davy Preuveneers, Paulo Novais: A survey of software engineering best practices for the development of smart applications in Ambient Intelligence. JAISE 4(3): 149-162 (2012)

Software engineering

- As a research discipline aims to address a systematic approach to the **analysis**, **design**, **implementation**, **testing**, and **maintenance** of software;

- **Ambient Intelligence** heavily relies on **software as a fundamental building block** to help develop intelligent and adaptive ubiquitous computing environments.



P. Naur and B. Randell, editors. Software Engineering: Report of a conference sponsored by the NATO Science Committee, Garmisch, Germany, 7-11 Oct. 1968, Brussels, Scientific Affairs Division, NATO. 1969.

Topics

- **Requirements elicitation process;**
- Reuse;
- Evaluate systems and applications.

Requirements elicitation and specification

- One of the (main) reasons why applications or software prototypes do not find their way to the general public is because they do not meet user needs or business demands.
- This is usually a sign of not having defined the right software requirements prior to the development of the application.

Davy Preuveneers, Paulo Novais: A survey of software engineering best practices for the development of smart applications in Ambient Intelligence. JAISE 4(3): 149-162 (2012)

Requirements elicitation and specification

- Engineering Requirements
  - The domain of requirements engineering attempts to address this challenge by offering a systematic approach for eliciting, analyzing, documenting, validating and managing software requirements.
  - We will focus on the elicitation process which deals with discovering and gathering a consistent and complete set of verifiable requirements from different customers, end-users and other stakeholders in the system.
  - Well-known techniques for requirements elicitation include interviews and questionnaires, requirements workshops, brainstorming with idea generation and idea reduction, use cases, and role-playing, etc.

Requirements elicitation and specification

- Elicitation of context-aware requirements
- Context = computing context, user context and physical context.
  - Determine the target groups of users within an interest in the system;
  - Estimate the context of use which may impact the interaction;
  - For each context, list the requirements specified for it;
  - Determine the user activities during the interaction with the system;
  - For each activity, investigate the impact of each context on the interactions;
  - For each context-aware feature, determine the desired context-aware capabilities;
  - Match the context-aware capabilities with the elicited requirements.

D. Hong, D. K. W. Chiu, and V. Y. Shen. Requirements elicitation for the design of context-aware applications in a ubiquitous environment. In Proceedings of the 7th international conference on Electronic commerce, ICEC '05, pages 590–596, New York, NY, USA, 2005. ACM.

Requirements elicitation and specification

- Requirements elicitation: end-users with limited computer skills, advanced end-users who are familiar with computer applications, and requirements engineers who are professional computer experts who must validate and formalize the specification of the elicited requirements.
  - Context scope:
    - the requirements engineer defines the role of the end-users and the domain of the system to be developed, and also adapts the tool accordingly.
  - System specification:
    - the end-users describe the main characteristics and select requirements from a predefined catalog and closed-option interfaces (users, policies, physical environment, services, devices, and service configurations).
  - Advanced system:
    - The end-users and requirements engineer refine the predefined requirements with new ones not available in the catalog. When finished, the requirements engineer adds them to the catalog.
  - Validation:
    - The requirements engineer and end-users validate the captured requirements, removes any ambiguities or mistakes, and creates a formal specification of the requirements.

F. Pérez and P. Valderas. Allowing end-users to actively participate within the elicitation of pervasive system requirements through immediate visualization. In Proceedings of the 2009 Fourth International Workshop on Requirements Engineering Visualization, REV '09, pages 31–40, Washington, DC, USA, 2009. IEEE Computer Society.

Requirements elicitation and specification
Remarks

- The importance to actively involve the end-user and to develop an elicitation process that is customized to the competences of the end-user;

- The need for an explicit representation of the context and goals of the user, and how the context impacts the interaction with the system:

- An explicit formalization of which requirements are relevant for a given context and how the requirements may evolve when the context changes.

Davy Preuveneers, Paulo Novais: A survey of software engineering best practices for the development of smart applications in Ambient Intelligence. JAISE 4(3): 149-162 (2012)

- Requirements elicitation process;
- **Reuse;**
- Evaluate systems and applications.

Reuse

- Why Reuse:
  - Systems are (usually) designed by composing existing components that have been developed or used in other systems;
  - Reuse is a key principle in software engineering;
  - Reuse is possible at different levels, ranging from simple functions to components or even complete application services.

Reuse

- Design and architectural patterns
  - Design patterns are well-known for offering generic and implementation independent abstractions for interactions that can appear across many applications.
  - Design patterns in software engineering provide a general repeatable solution to a commonly occurring problem in software design.

- Midleware
  - Middleware is typically software that sits in the middle in between the applications and the underlying operating systems;
  - It facilitates distributed processing as it can connect multiple applications or heterogeneous components deployed over a network to form a larger application;
  - A middleware approach for developing ubiquitous computing applications is without a doubt the most popular approach to stimulate reuse;
  - They can successfully deal with the heterogeneity in sensor and actuator networks, simplify the portability of smart applications to other hardware and software platforms, and facilitate the development of context-aware distributed applications.

- Feature models and software product lines
  - SPL potentiate the use of common features, linear to the development of a project, based on the concept of sharing software, tools and methods;
  - Based on production lines, the SPL absorbs the notion of one part to multiple pieces, which leads to a very specific design and structures of the parts in order to be fitted in the pieces;
  - Feature models as such are used to denote SPL where a software product line is a set of software products, and a software product (or application) is a set of features and can be adapted in different ways for different customers;
  - The major benefit of software product line-based software engineering technique for the development of Ambient Intelligence applications is that it provides explicit documentation of variability.

- Aspect and Context Oriented Programming
  - Many context-aware applications have the functionality for context management and the decision logic for smart and adaptive application behavior scattered throughout the application's base code, causing tangled code that is difficult to understand and maintain;
  - Aspect Oriented Programming (AOP) is a software engineering technique that aims to modularize these types of concerns at the level of source code and as such allows for separation of cross-cutting concerns.

Topics

- Requirements elicitation process;
- Reuse;
- **Evaluate systems and applications.**

Evaluation methods

- With the proliferation of ubiquitous computing systems in ambient assisted living and emergency scenarios, we need safety-critical applications whose functional and non-functional correctness can be verified;
- The correctness of a system model does not imply that implementing the system is correct.
  - Formal verification
  - Simulation and test-case generation

Opportunities

- The key challenge that we addressed was the quest for a solid methodology with best practices, procedures, methods, and techniques for designing and developing smart applications and systems;
  - Early evaluation of non-functional concerns;
  - Adaptation trade-offs and impact analysis;
  - Design for failure.

Agenda

- Motivation
- Vision
- Projects and Trends
- Projects @ UMinho
- Development of applications
- **Final considerations**
- New paths

Contributions

- AmI Vision as a Multiagent System;
- Dealing with incomplete information;
- Architecture for AmI based on agents and services;
- Learning;
- Context awareness;
- Application to concrete domains.

Final Considerations

- Major change in research:
  - The first year's goals envisioned the maximization of the productivity of its users;
  - We are now focusing on environments that assist:
    - in a more balanced way;
    - instead of empowering.
  - The line of research presented here is governed by the same principles, aiming to obtain non-invasive environments, with an essentially supportive role.

Agenda

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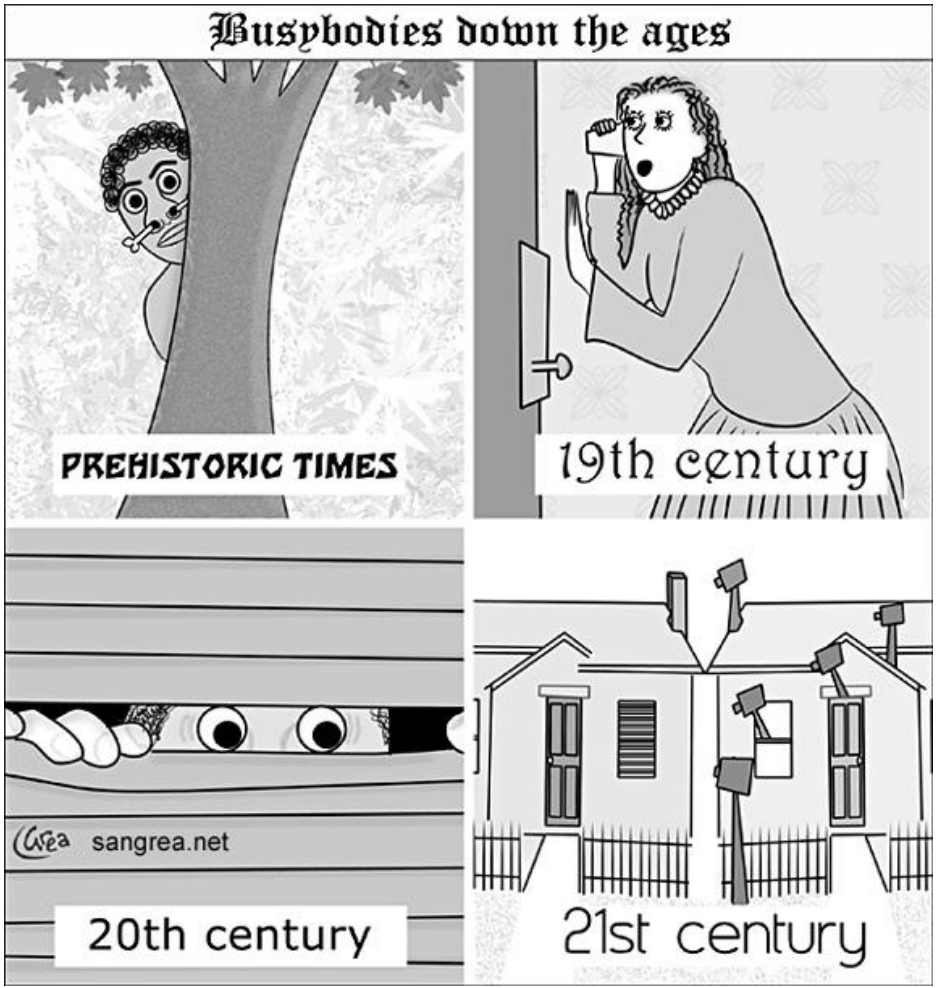
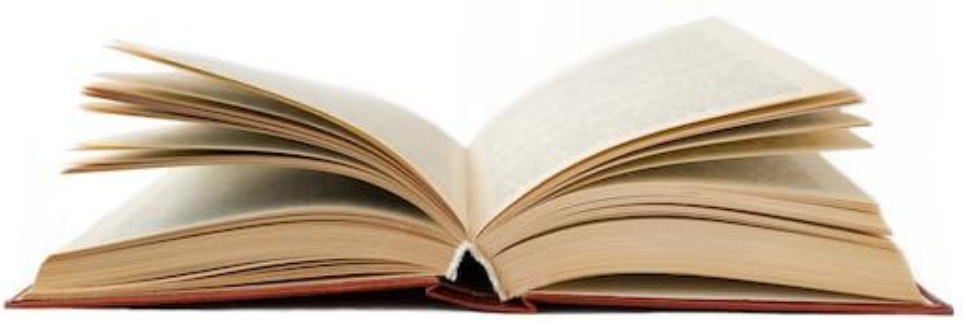
News Paths?


Busybodies down the ages
PREHISTORIC TIMES
19th century
sangrea.net
20th century
21st century

Recent references on the topic

- Miguel J. Hornos, Carlos Rodríguez-Domínguez: Increasing user confidence in intelligent environments. J. Reliable Intelligent Environments 4(2): 71-73 (2018)
- Aditya Santokhee, Juan Carlos Augusto, Carl Evans: Engineering Intelligent Environments: Preliminary Findings of a Systematic Review. Intelligent Environments (Workshops) 2018: 57-66 (2018)
- Miguel J. Hornos: Application of Software Engineering techniques to improve the reliability of Intelligent Environments. J. Reliable Intelligent Environments 3(1): 1-3 (2017)
- Juan Carlos Augusto, Miguel J. Hornos: Software simulation and verification to increase the reliability of Intelligent Environments. Advances in Engineering Software 58: 18-34 (2013)



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Departamento de Informática

Sensorização e Ambiente

Oportunidades, Desafios e Ameaças

SA @ Perfil SI, MEI
2º sem, 2024/2025