Extending a smart home multi-agent system with role-based access control

International Conference on Internet Technologies & Society 2014

10 – 12 December
New Taipei City, Taiwan

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Outline

- Introduction and context
- Background
- Home Manager: new scenario
- Future Work
- Conclusion

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  - Context
  - Home Manager 1.0
  - The new objectives
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Context

- Home appliances / devices becoming smarter and connected
- New pervasive scenario in many application fields
  - Remote appliance monitoring /control for
    - energy saving
    - air conditioners control
    - ...
  - Domotics
  - Ambient Intelligence (AmI)
  - Smart Environments
  - ...

Focus onto ***people's need***:

- User-friendliness
- User-empowerment
- Support for human interaction

Home Manager 1.0

- Agent-based application for the control of an intelligent home
- Designed according to the **SODA** agent-oriented methodology
- Implemented on the top of **TuCSoN** multi-agent infrastructure

Basic set of home appliances / devices

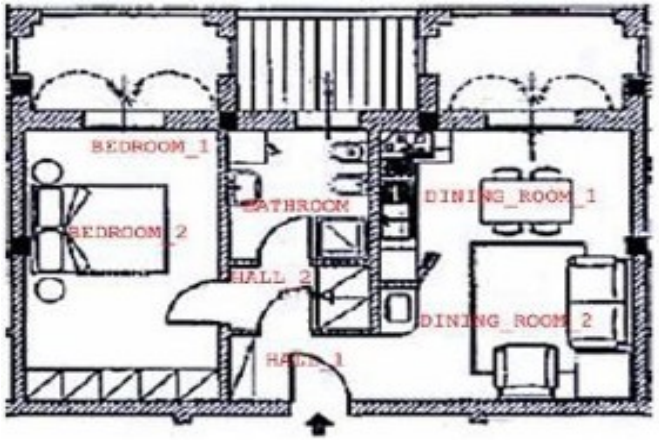
Basic support to policies and user goals

Users preferences

Basic access control model

Very limited policies

(Too) simple scenario



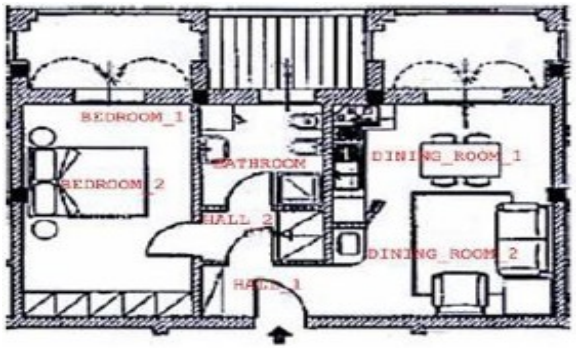
Extending Home Manager

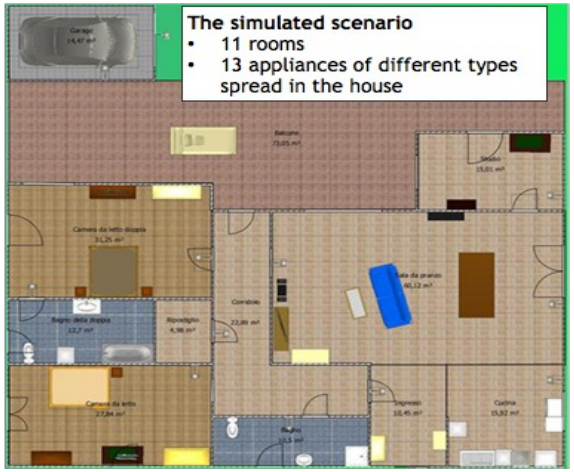
Home Manager 1.0

- Access control model
- Limited policies
- Simple scenario

New Home Manager

- RBAC Engine
- Configurable RBAC
- Larger scenario





New Objectives

- Designing an agent-based RBAC engine taking into account
  - User Role(s)
  - Presence/State of the room
  - Hour of the day and Date/Days of week
- Further stressing the SODA methodology in a richer & larger testbed
- Testing effectiveness & robustness of TuCSoN in a more complex scenario
- Laying the foundations for “pervasive” and “ubiquitous” extensions according to the Butlers perspective

The Butlers vision (Denti, 2014)

the intelligent *butler* handles the appliances w.r.t. user goals and configurable policies

anticipates the user's needs by exploiting any kind of user information (position, habits, mood..)

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  - TuCSoN
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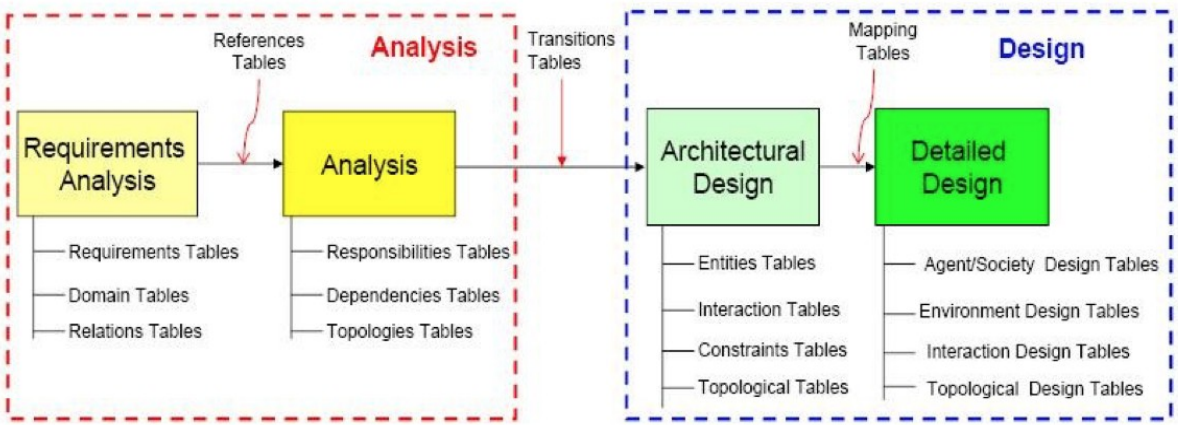
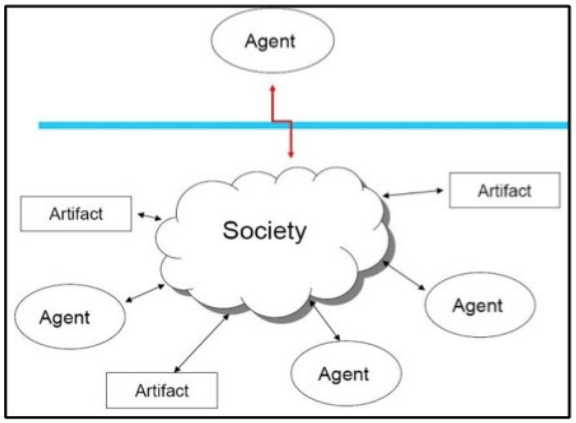
The SODA Agent-Oriented Methodology

SODA *(Societies in Open and Distributed Agent spaces)*: AOSE methodology for the analysis and design of *agent-based systems* based on the *Agents & Artifacts (A&A)* meta-model [Molesini et al. 2008]

The *SODA process* is organised in two phases (each made of two sub-phases)

- *Analysis phase (*Requirements Analysis and Analysis steps)
- *Design phase* (Architectural Design and Detailed Design steps)





Main concepts:

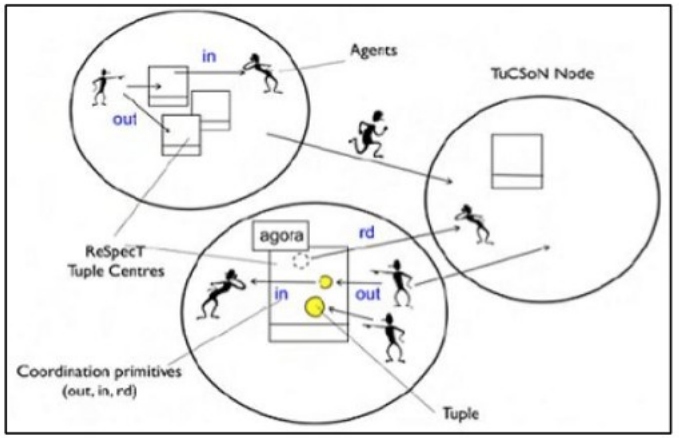
- workspace as an open set of *agents* (*active* part) and *artifacts* (*reactive* part)
- explicit specification on how they *relate* (*interaction* rules)

The TuCSoN model and infrastructure

TuCSoN *(Tuple Centres Spread over the Network)* is a model and infrastructure for the coordination of distributed processes, as well as of autonomous, intelligent & mobile agents [Omicini and Zambonelli, 1999]

- TuCSoN agents are the *coordinables*
- Tuple centres (TC) are the ***programmable*** *coordination media*
- TuCSoN nodes represent the basic *topological abstraction (*host the TCs)

Agents interact by exchanging tuples on tuple centres, via the *TuCSoN coordination primitives*



RBAC for Multi-Agent Systems

- RBAC is an ANSI/INCITS standard (# 354-2004)
- *Role* as the key concept for defining and enforcing permissions & rules
- Policy-neutral, easier to extend, can express DAC/MAC models
- Supports both static and dynamic *separation of duties* (SSD / DSD)

RBAC-MAS is a model for an RBAC-like organisation of MAS...ref
- RBAC general concepts tailored to MAS specificities
- (and to the SODA process..)

- Roles, sessions, and policies mapped on MAS *runtime entites*
- Dynamically management via infrastructural services
- Clear separation between mechanisms and policies
- Two sub-systems:
  - RBAC as Agent Classes,
  - Role (Agent) behaviour defined as *Actions* and *Perceptions*

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Home Manager: policy design

- ***An Access Control Model for Home Manager***
- "Positive permission" approach
  - Roles & permissions
    - Parent — the house administrator
    - Son — can use any appliance, but has no administrator rights
    - Child — restrictions apply on devices and room access
    - Cleaning lady
    - Guest
    - Unknown user — an unrecognized person, possibly an intruder)
  - Device types
  - Ambient constraints for both rooms and appliances

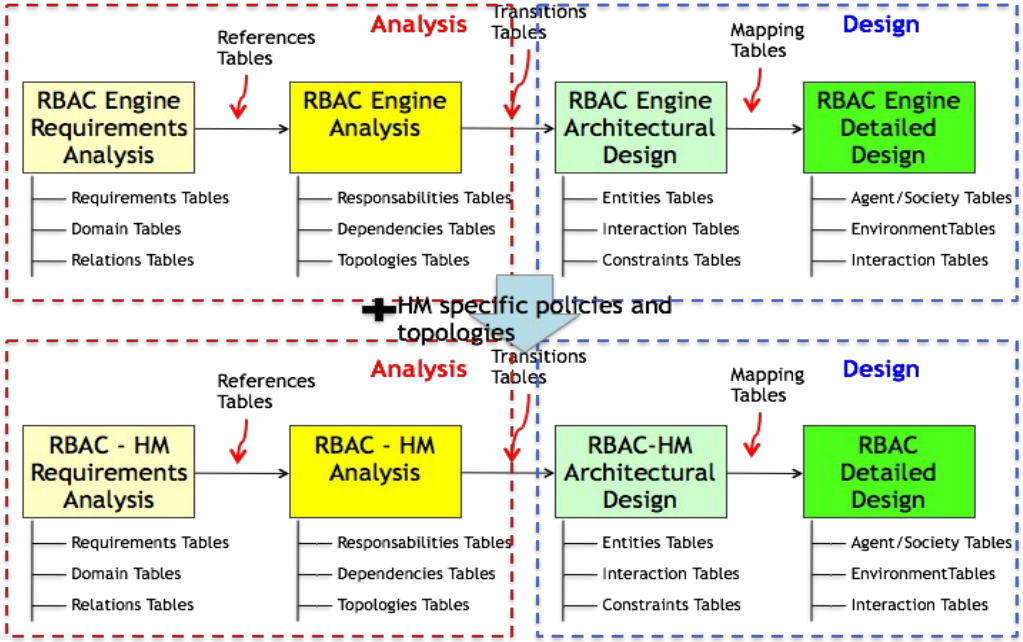
- ***Specific policies of interest: energy saving & user comfort***
  - Environment aspects → lighting & heating
  - Essential vs unessential appliances

The (Home Manager) RBAC engine

GOAL: ***keep the RBAC engine as independent as possible of the HM case***

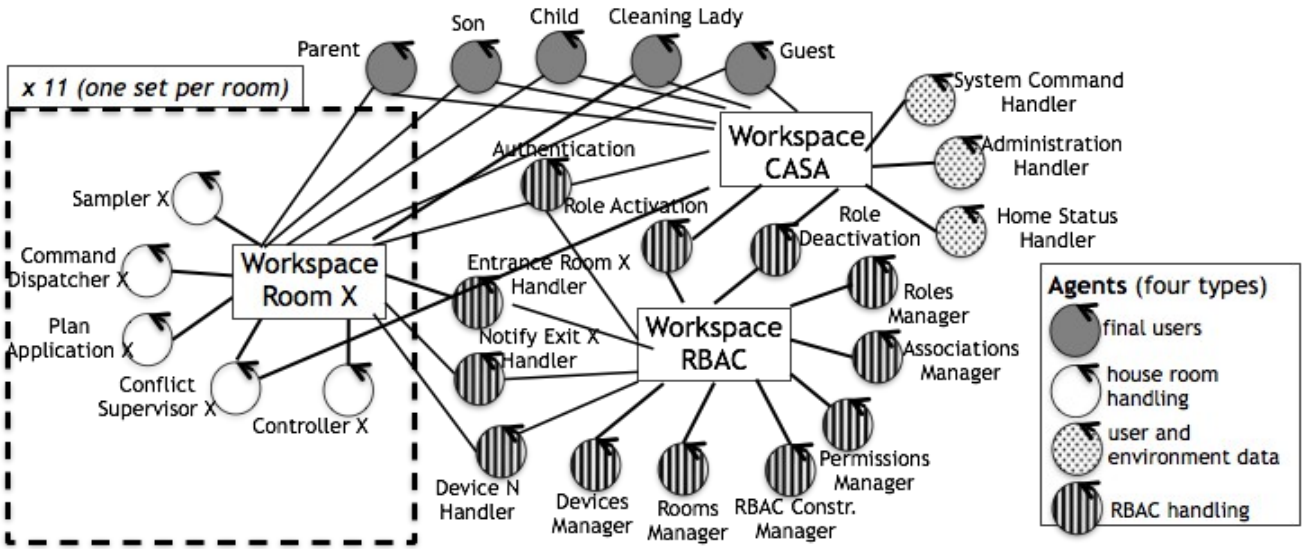
APPROACH: apply the SODA process twice:

- **First,** to design an RBAC control mechanism for a *(generic) private building*
- **Then,** to add the *Home Manager-specific* policies and house topology.



The new Home Manager Architecture

- **SODA design entities are mapped onto proper TuCSoN abstractions:**
  - Coordination laws and system policies onto suitably programmed tuple centres
    - Environment information:one tuple centre “HOUSE”
    - Data and RBAC policies: one tuple centre “RBAC”
  - One workspace per room, one tuple centre per workspace
  - Four agent types: the three above + final users



The new scenario in detail

- Details
  - 11 rooms
  - 13 devices
  - Lighting, Conditioning and Rolling Shutters control
- Role Based Access Control on appliances and rooms
- More complex policies for user comfort and energy saving

Roles and permissions

- parent, child, baby, cleaning lady, visitor

Appliances classes and constraints

- switchable / un-switchable devices (A/C, fridge, …)
- environmental constraints for room and appliances
  - private bathroom reserved by selected user(s) at given times
  - TV accessible to children after 8pm only with parental control

Lighting and comfort policies / preferences

- user preferences conjugated with house policies
- external factors (light, temp) taken into account
- conflict management policies

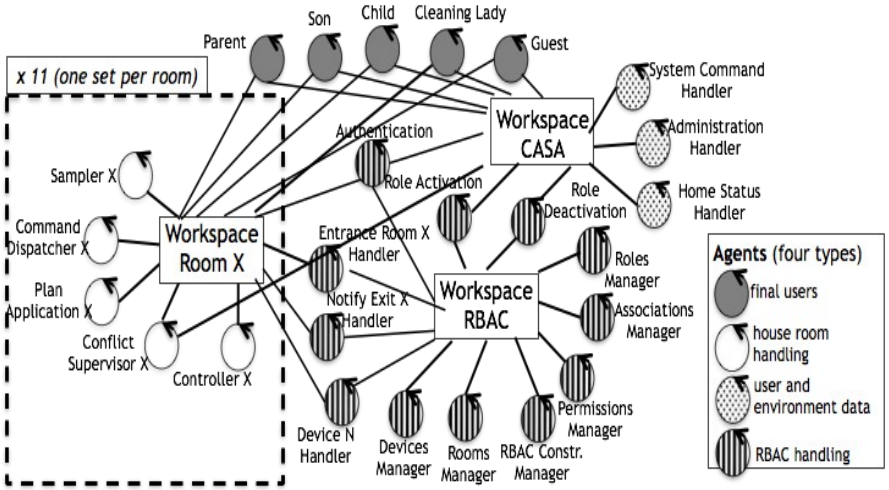
The overall system structure

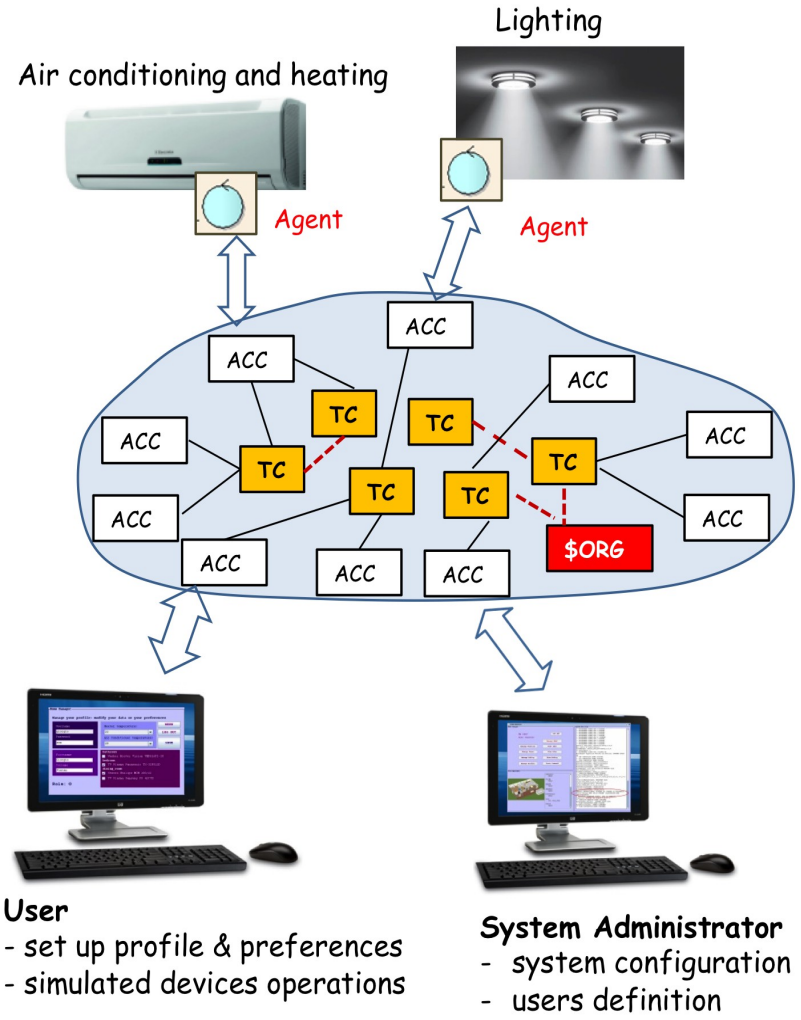
- 13 tuple centres
- 4 agent types with dozens of agents
- 1 DBMS to store user info and appliance info

The simulated scenario

- 11 rooms
- 13 appliances of different types spread in the house

From architecture to implementation



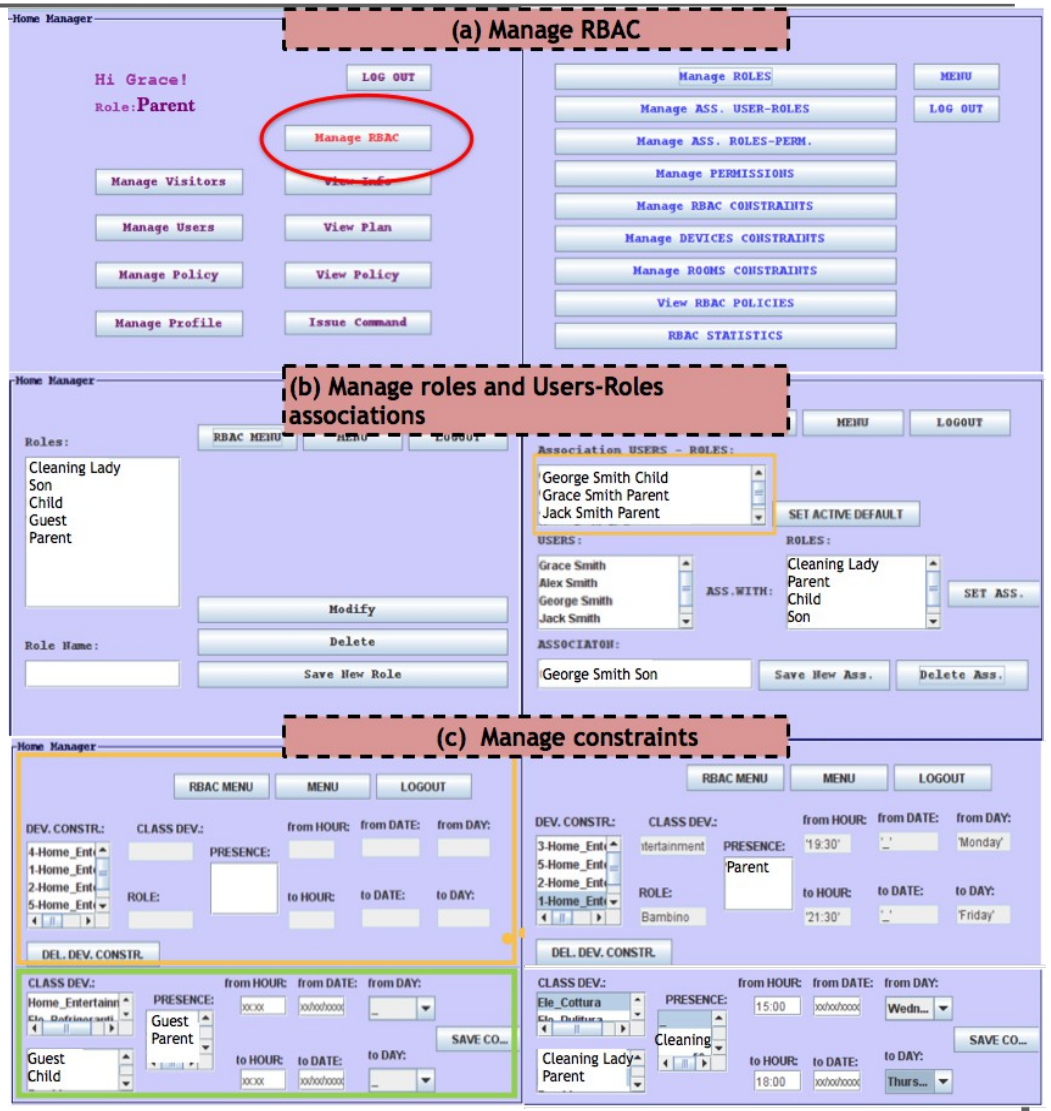


User
- set up profile & preferences
- simulated devices operations

System Administrator
- system configuration
- users definition

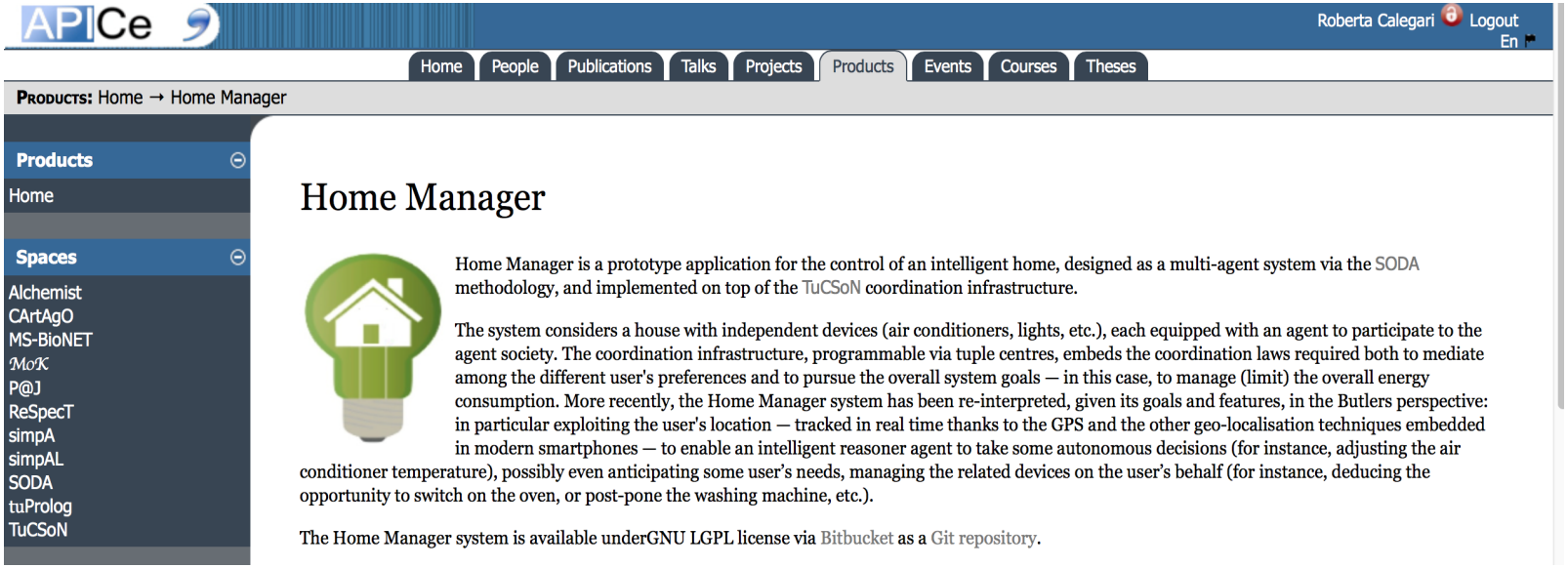
Home Manager: implementation

- *GUI* to operate on roles, policies, and constraints
- Configurability
- No need to know the TuCSoN specification languages



Home Manager: home sites

- http://apice.unibo.it/xwiki/bin/view/Products/HomeManager
- https://bitbucket.org/tuprologteam/homemanager



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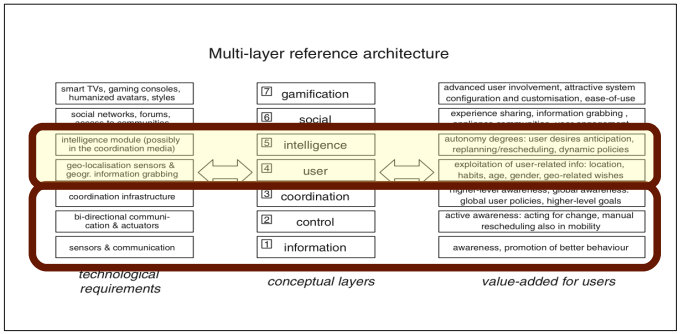
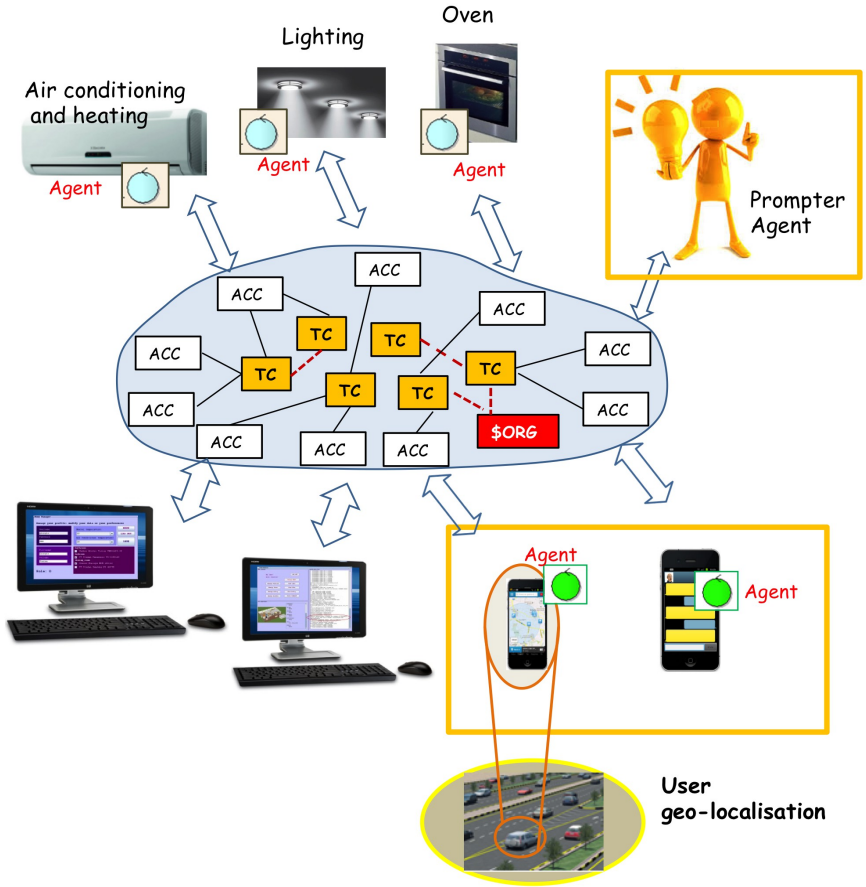
Future work

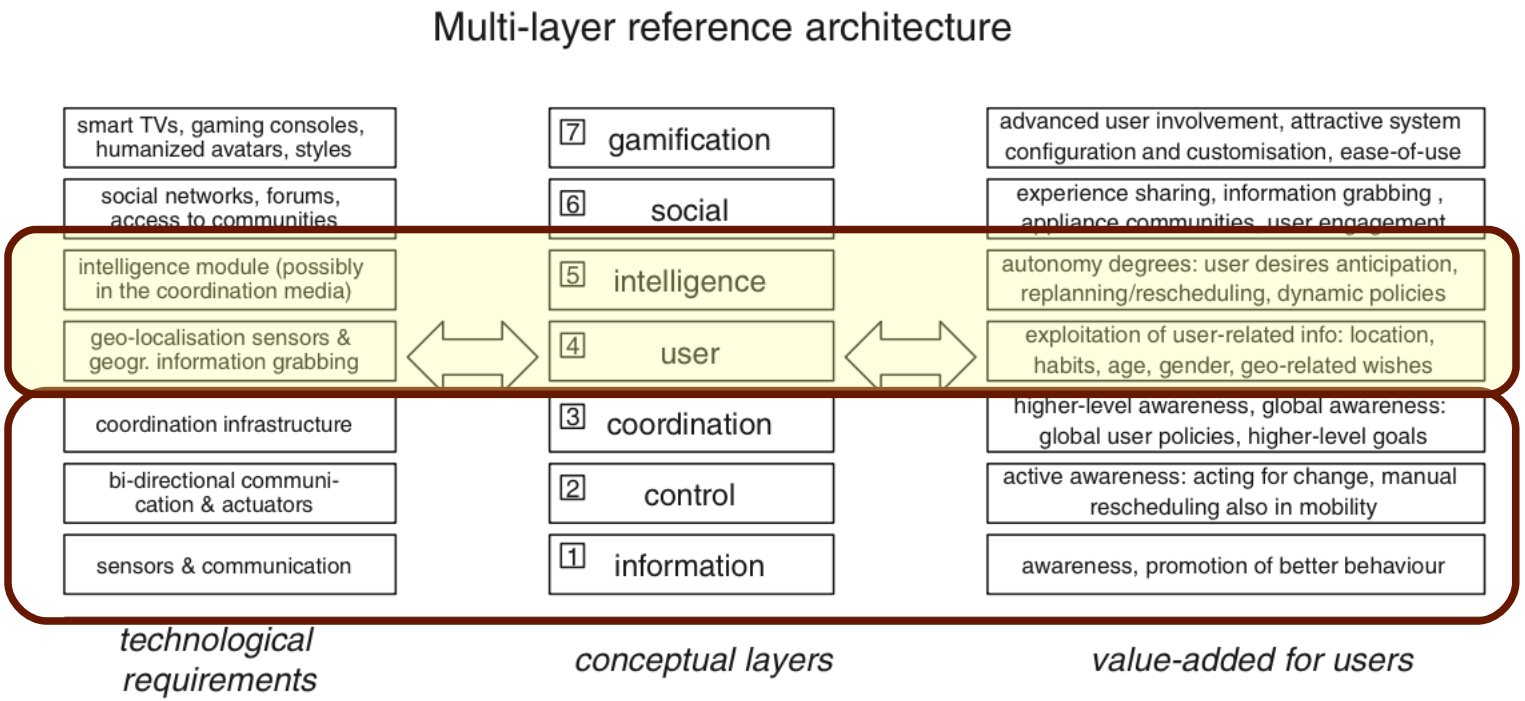
Extension towards ***pervasive*** and ***ubiquitous*** contexts

- Remote control capabilities
- Exploitation of the user's profile (habits, personal knowledge, etc.)
- Exploitation of dynamic data (location, situation, etc.)
- Smarter behaviour according to the *Butlers* perspective





Next step: Home Manager "Butler-isation"



Conclusion

- RBAC engine successfully deployed onto an AmI scenario
- SODA & TuCSoN pros & cons
  - SODA proved effective, two-phase process also supported
  - TuCSoN proved effectively able to govern a heterogeneous system
  - Huge amount of SODA tables is a critical limit → *tools needed*
  - Tuple centre specification languages out-of-reach for end users → GUI
- Pervasive extensions
  - Butlers perspective
  - Next step: exploit user's geo-localisation to provide advanced services (anticipate some possible user's needs)

Thank you.

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