IARIA

Laboratoire DOMUS
Recherche en domotique et en informatique mobile

UNIVERSITÉ DE SHERBROOKE

A Do-It-Yourself Approach to Ambient Assisted Living

Sylvain Giroux

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Transdisciplinary ecosystem

- **Domus Lab, University of Sherbrooke**
  - 3 professors, 6 research assistants, 11 PhD students, 3 trainees

Universities and research organizations

Université de Montréal

UQAC
Université du Québec à Chicoutimi

HEC MONTRÉAL

ENIB
ÉCOLE NATIONALE D'INGÉNIEURS DE BREST

UR | UNIVERSITÉ DE LA RÉUNION

Centre de recherche iugm
Institut universitaire de gériatrie de Montréal

Centre de recherche sur le vieillissement

Funding agencies

CRSNG NSERC

IRSC CIHR
Instituts de recherche en santé du Canada | Canadian Institutes of Health Research

Fonds de recherche Santé Québec

AGEWELL

MEDTEQ+

Private corporations

VIDÉOTRON

HOSPITALIS
CHANGE LA VIE !

Governments and healthcare organizations

Québec

Centre intégré universitaire de santé et de services sociaux du Centre-Sud-de-l'Île-de-Montréal

CISSS de la Montérégie-Centre

Centre de recherche et d'expertise en gérontologie sociale

CENTRE DE RÉADAPTATION ESTRIE

Ville de Côte Saint-Luc | City of Côte Saint-Luc

Not for profit organizations

Fondation BERTHIAUME-DU TREMBLAY

RÉSEAU Accorderie

LM | FONDATION LUC MAURICE

NUMANA

Examples of on-going projects

- Home support for vulnerable elderly people: co-design and deployment of technological solutions in a living laboratory, 2017-2022, $978 K
- Development of intelligent housing for seniors to remain at home in the environment of their choice; at Le 1615 & Le 1625 residences in Le Quartier des Générations, 2020-2023 $ 1 014 K
- Communities supporting the life trajectory of Aboriginal and non-Aboriginal people with dementia, 2021-2024 $939 K
- Living at home with a good support network (Accorderie), 2021-2024, $196 K
- Smart environments in support of the frail and isolated senior ecosystem: The City of Côte Saint-Luc's Living Lab, 2021 – 2024, $708 K
- DOMAID: Support tools for diagnosis and assistance in occupational therapy, 2020-2023, $254 K + 249 euros

Plan

- A transdisciplinary approach to cognitive assistance and telemonitoring
  - IoT, AI, participatory design, and living labs
- Three case study
  - Cognitive assistance for meal preparation
  - Overnight accompaniment
  - Telemonitoring of activities of daily living over long periods of time
- NEARS
  - DIY : On building your own smart home

Main issue

- How to design relevant assistive technology for cognitively impaired people ?
  - Stakeholders
    - Cognitively impaired people
    - Professional and natural caregivers
    - Administrations
    - Interdisciplinary teams
  - Approaches
    - Internet of things / Ambient intelligence
    - Participatory design / Interdisciplinarity
    - Living labs

Objectives

- Provide adapted and personalized ambient cues to
  - Foster the autonomy of cognitively impaired people
  - Reduce risks and hazards
  - IoT and ambient intelligence

- Keep ensuring cognitive assistance outside people's home

- Keeping in touch with family and caregivers
  - Telemonitoring over short periods of time
  - Assessments over long periods

- Personalization and context-awareness
  - People : cognitive abilities, habits, preferences, occupational profiles…
  - Environment : home, residences, cities…
  - Interactions

Different living labs for different purposes

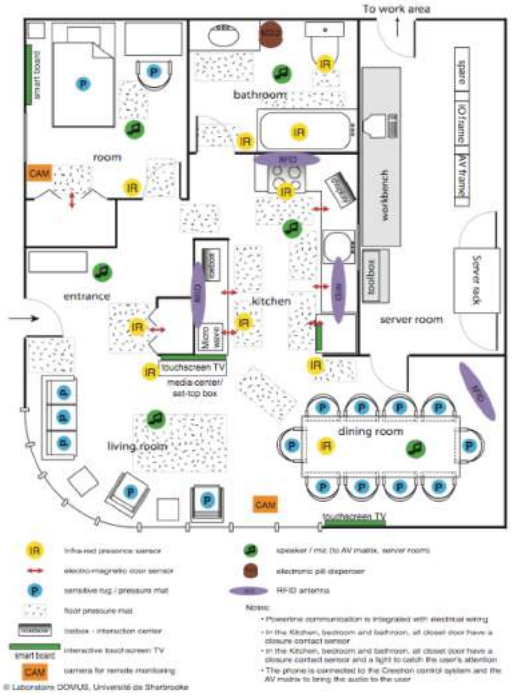
- Simulated housing

- Structured Living Lab

- Into the wild

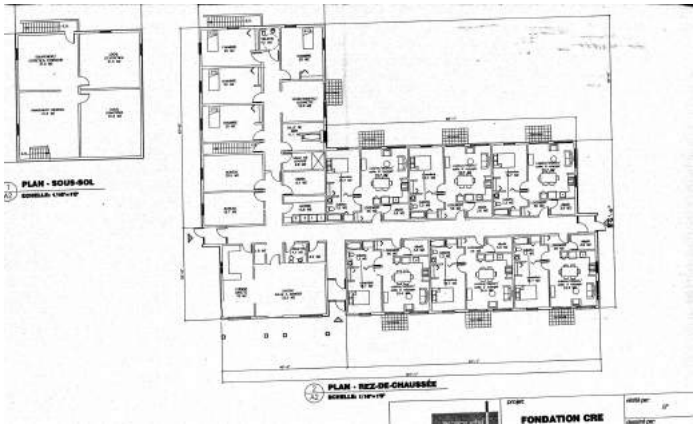
Different living labs for different purposes

- **Simulated housing** : a smart flat on the campus
  - Artificial, long term installation
    - Reproducing accurately what occurs at home
  - High number of wired sensors and effectors.
  - Well-know and unchanging spatial topology.
  - Precisely scripted.



Different living labs for different purposes

- Structured Living Lab
  - Real life, long term installation.
  - High number of wired sensors and effectors.
  - Well-know and unchanging spatial topology
  - Loosely scripted or not scripted at all.
  - A nursing home for people with severe traumatic brain injuries
    - 4 km from the University of Sherbrooke



Different living labs for different purposes

- Into the wild
  - Real life, short-lived agile installation.
  - A limited number of mobile and wireless sensors and effectors .
  - Highly variable spatial topology.
  - Loosely scripted or not scripted at all.

Three case studies

- **Cognitive assistance for meal preparation**
- Overnight accompaniment
- Telemonitoring of activities of daily living over long periods of time

➔ care-ready scenarios

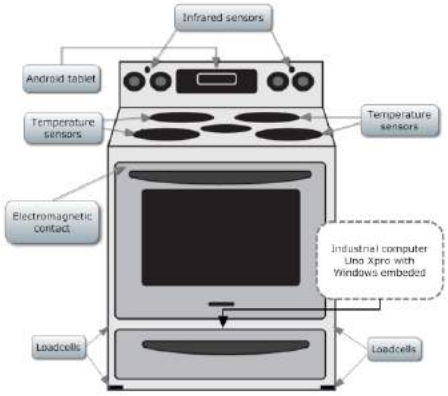
COOK, a truly interdisciplinary research project

3 axis

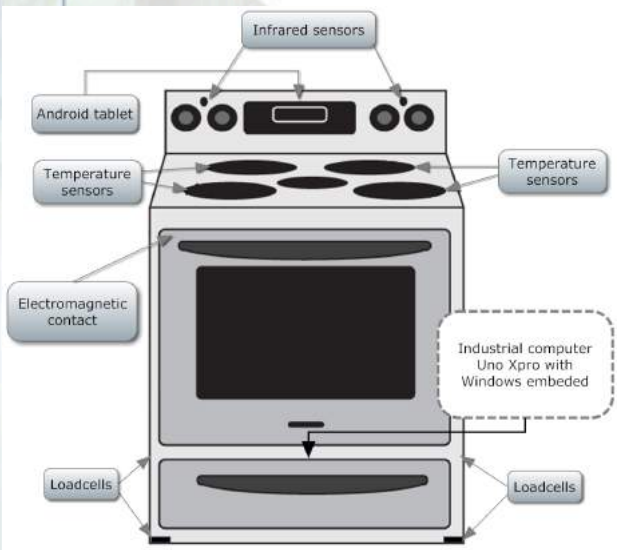
- Effects : measuring benefits and satisfaction
- Technology: building a cognitive assistant for meal preparation
- Implementation in organizations: Dos and don't. Guidelines. Strategies.

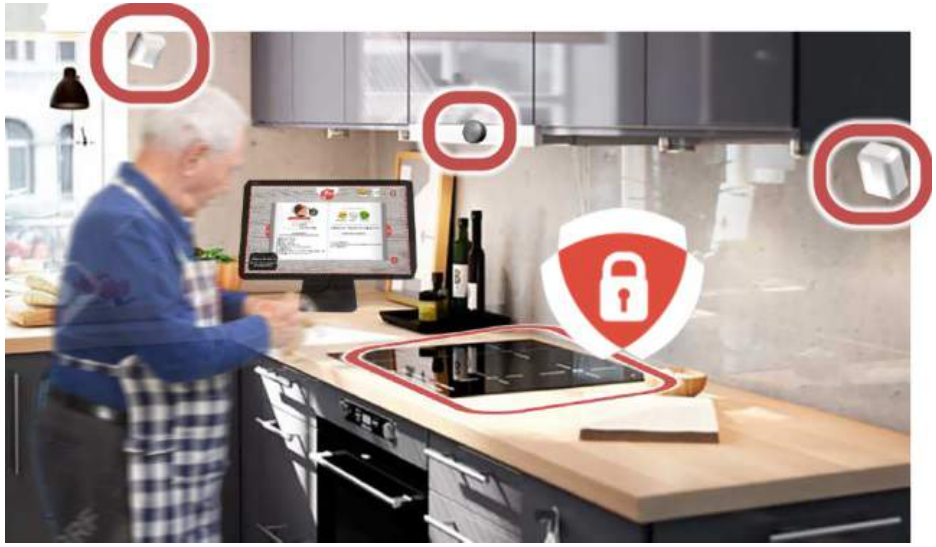
Transdisciplinary project / Participatory action research

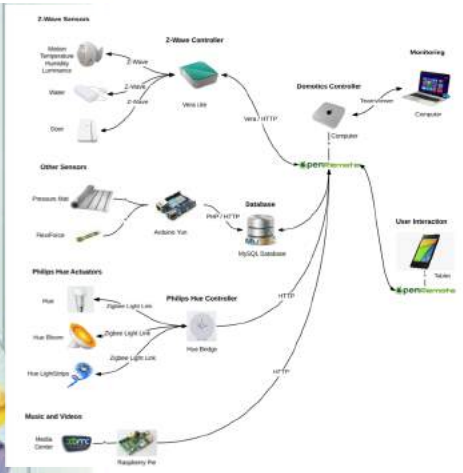
- Occupational therapy. Computer science. Speech and language pathology. Ergonomics. Industrial Design.
- Person with TBI. Family. Professional caregivers. Personal support workers. Administration. Firemen.



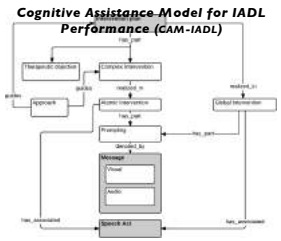
Hardware and software

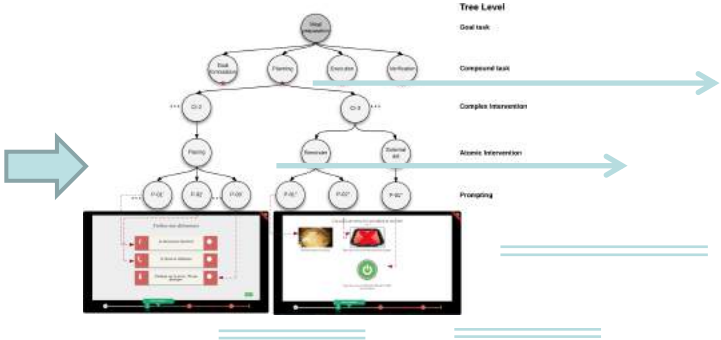






Cognitive remediation & prevention of fire hazards





Some nice outcomes resulting from introducing Cook in participants' life

The 3 participants

all of whom were living in long-term care homes prior to the study,
now living in an adapted living environment
now allowed to prepare hot meals by themselves with COOK

- Increased level of independence, self-analysis, and self-esteem
- Well integrated in the residence workflow

- Other effects
  - Less prone to anger
  - New perspectives on resident by caregivers

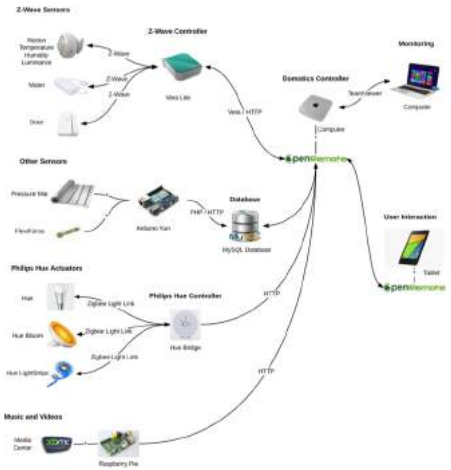
Three case studies

- Cognitive assistance for meal preparation
- **Overnight accompaniment**
- Telemonitoring of activities of daily living over long periods of time

➔ care-ready scenarios

Overnight Accompaniment

- Providing a calm and smart environment.
- Assisting the elder when he wakes up at night
  - Going to the bathroom / Being hungry / Being anxious
- Personalization of the assistance
  - Flat configuration / Learning elder habits / Visual and audio cues



Three case studies

- Cognitive assistance for meal preparation
- Overight accompaniment
- **Telemonitoring of activities of daily living over long periods of time**

➔ care-ready scenarios

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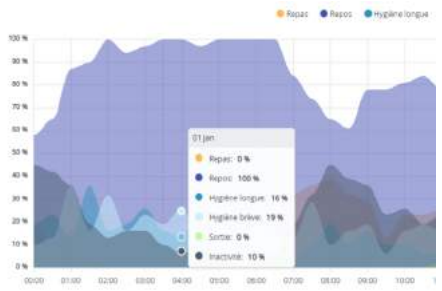
SAPA Telemonitoring of activities of daily living over long periods of time

- Professional caregivers (+ elders)
  - Decision support system : personalization of the services offered
  - Reports preserving privacy and easy to understand
  - Activities monitored : sleep, cooking, level of inactivity, presence (exits), hygiene
  - No notifications for emergencies

Standard IoT kit



Three case studies

- Cognitive assistance for meal preparation
- Overnight accompaniment
- Telemonitoring of activities of daily living over long periods of time

➔ **care-ready scenarios**

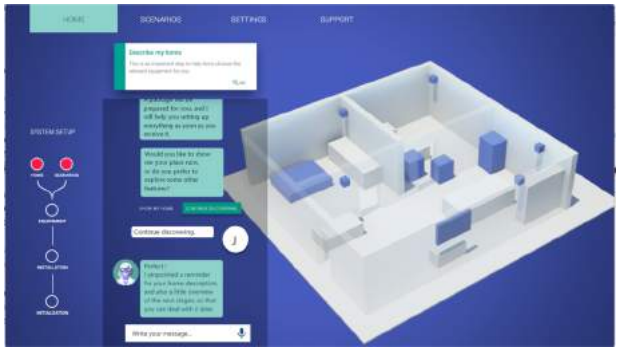
➔ **A Do-It-Yourself approach to smart homes**

NEARS
Fostering independent ageing in place

- Empowering end users
  - Elders and caregivers have the knowledge
- Do It Yourself
  - Carers (or other stakeholders) as peers
  - Let stakeholders make their own decision regarding what they can handle
- NEARS
  - a functional kit that assists carers and elders
    design, installation, evolution, and operation
    of their own customized AI-based smart home

Codesign : human ←→ AI

- Dashboard
  - 3D model of the home
  - AI : ontology (space, objects, IoT, activities of daily living (ADL))
  - Planning : hierarchical tasks modeling (scenarios)
  - Case-based reasoning
  - AI : activity recognition



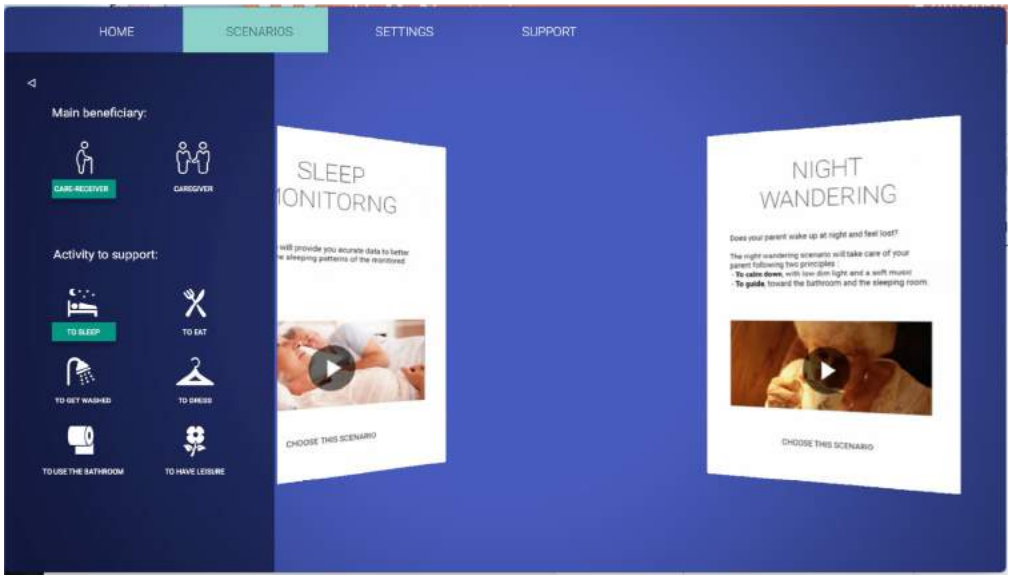
- Advanced Human-Machine Interfaces
  - Full-fledged augmented reality

Design

- Express and identify user needs
- Telemonitoring and assistance to activities of daily living (ADL)
  - Prepackaged care ready scenarios
  - New scenarios
- Customizing a scenario to one's residence
- A blueprint for a customized smart home

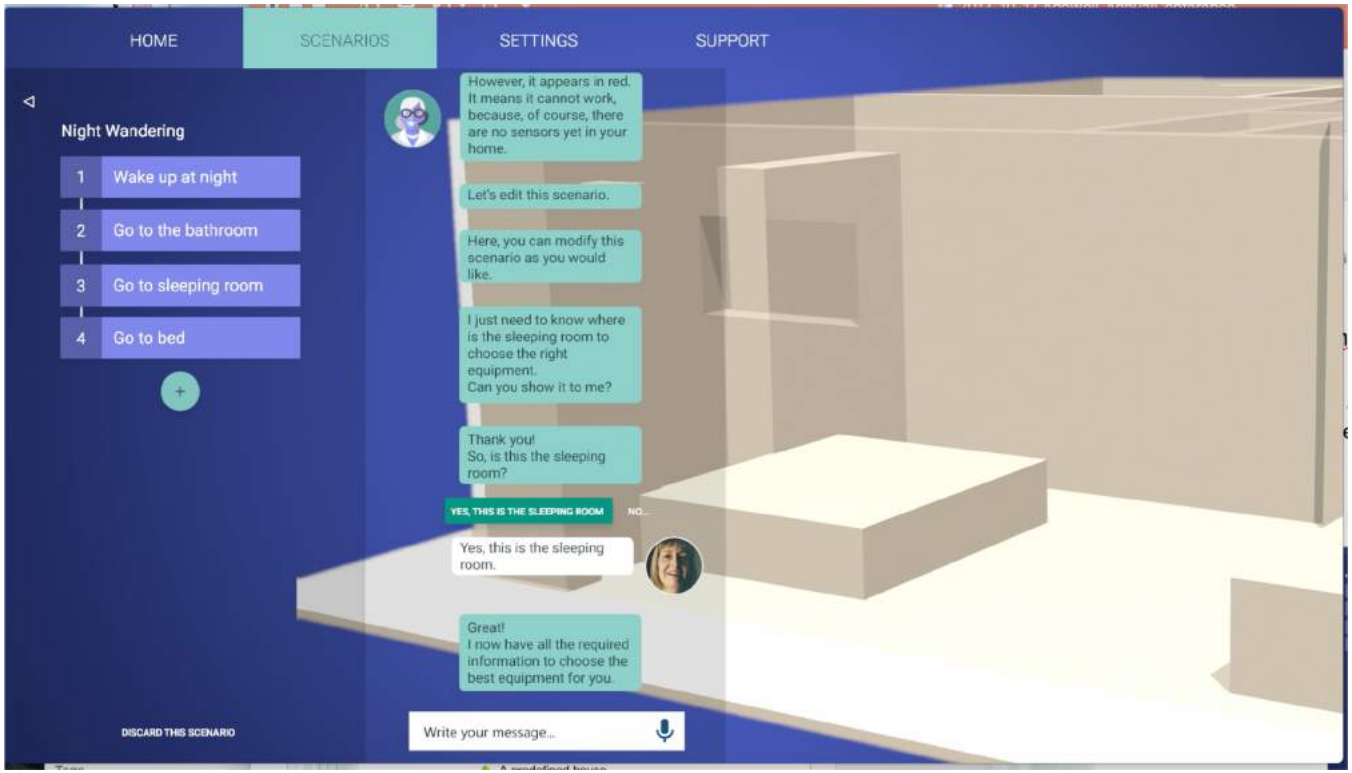
Design : scenarios

- Care ready or new scenarios for monitoring and assistance to ADL



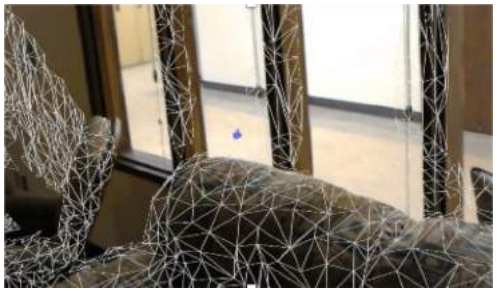
Night wandering scenario

« When my mother wakes up at night,
she wants either to go to the bathroom, go the kitchen because she is hungry, or to go to the TV room to relax because she is anxious.
Then she has to come back to bed to sleep »



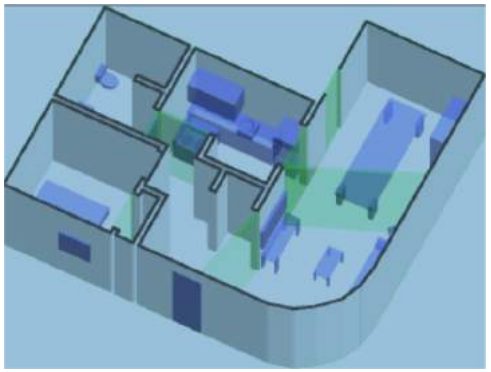
Design
Customizing a scenario to one's residence

- Co-creation of a semantic model of the home
  - **3D model, rooms, objects,** IoT. ADL,
- Show me the TV room. Show me the sofa.



Scanning the flat

Building a semantic wall



3D Model

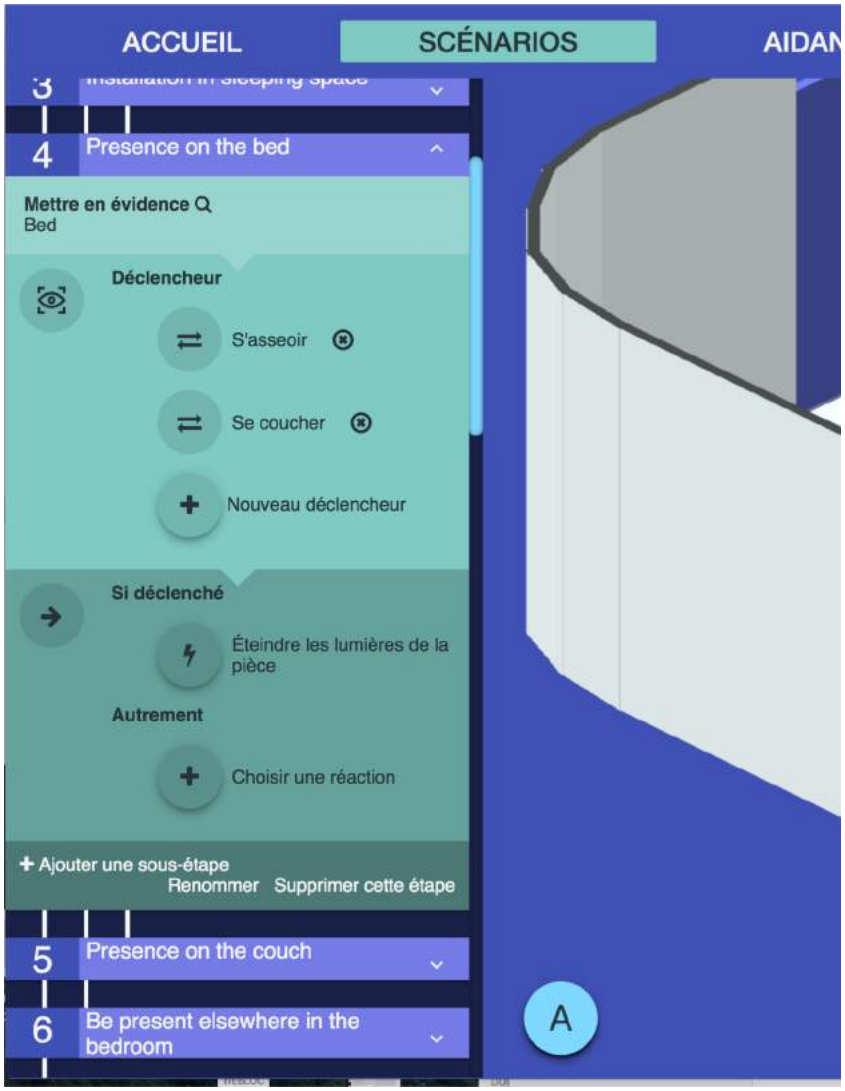
Design
Customizing a scenario to one's residence

- Co-creation of a semantic model of the home
  - 3D model, rooms, objects, ADL, sensors
- **Show me the TV room. Show me the sofa.**

Identifying objects of the scenario

Design : Creation of a new scenario I

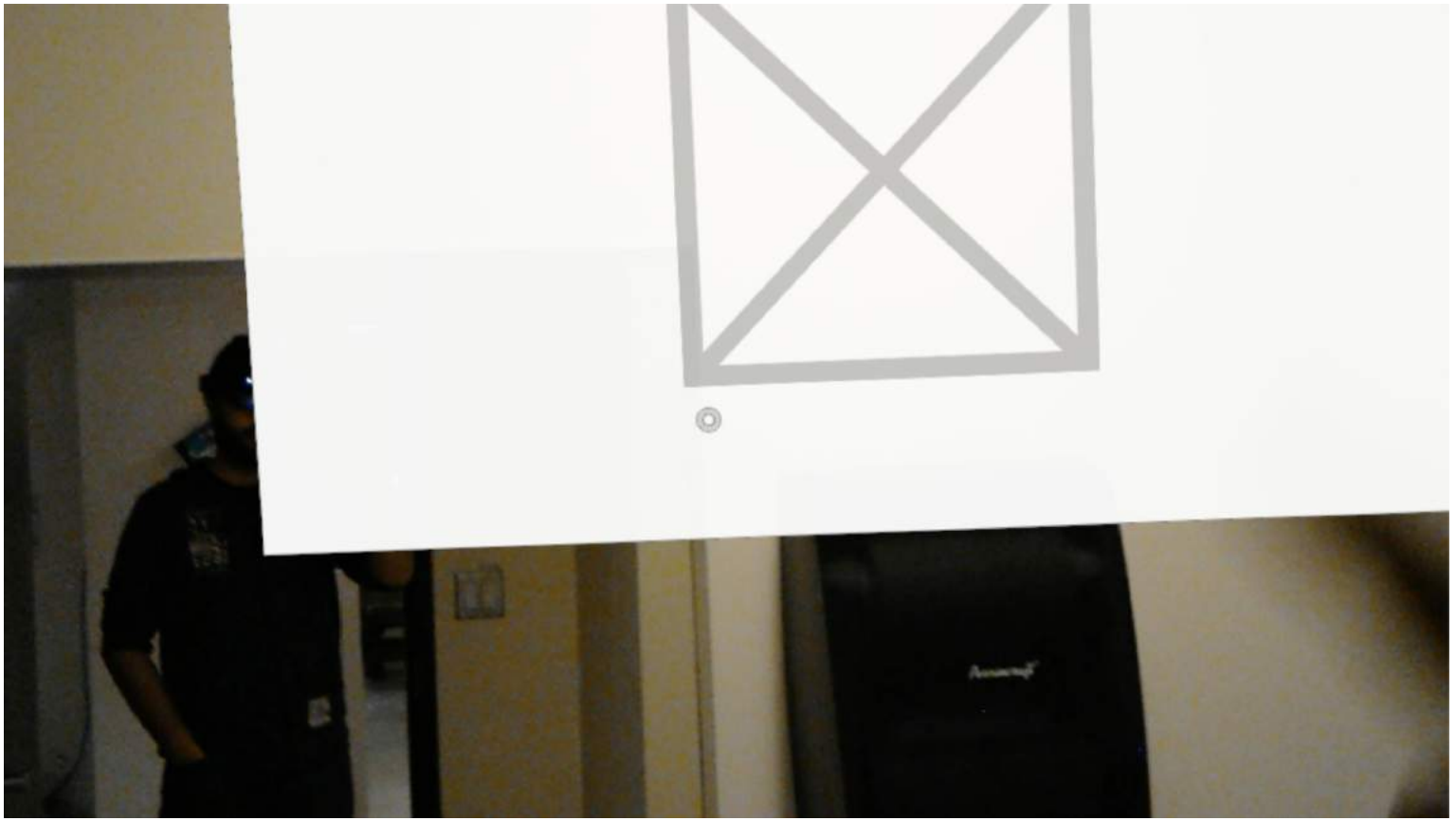
- DASH-DIY
  - Build an HTN of simple and compound actions
- HOME-3D-DIY
  - Show physically what has to be performed
    - Go into the bedroom, select action possible on the bed, etc.



Design : Creation of a new scenario II

“ If my mother wakes up at night
and try to leave the house,
play a message “Mommy stay at home”
and inform me by SMS ”

- HOME-3D-DIY
  - Show physically what has to be performed
    - Go into the bedroom, select action possible on the bed, etc.

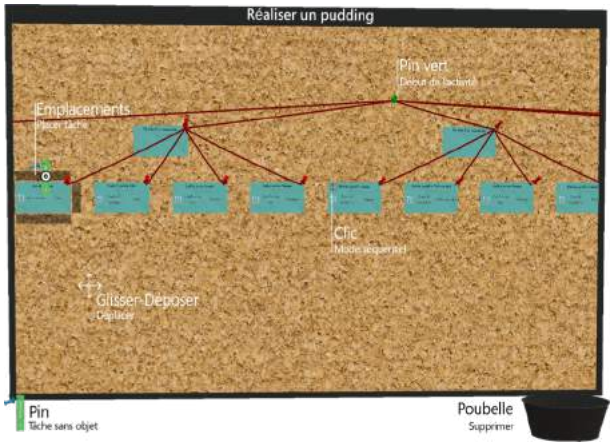


Design : Creation of a new scenario III

" If my mother wakes up at night
and try to leave the house,
play a message "Mommy stay at home"
and inform me by SMS "

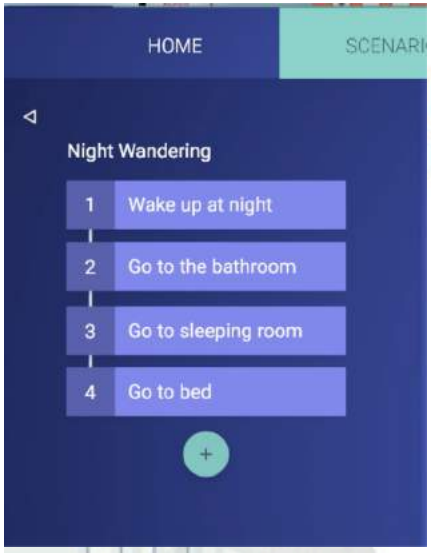
- HOME-3D-DIY
  - Show physically what has to be performed
    - Go into the bedroom, select action possible on the bed, etc.

- Proposing actions and building the task model in situ
  - Ontology
  - Case-based reasoning
  - Mixed reality



Design
A blueprint of a customized smart home

- An IKEA-like blueprint
  - An optimal set of sensors and actuators
    - Reliability, accuracy, price…
  - Sensors and actuators locations
    - Rooms, furnitures…
  - Assembly instructions
    - Batteries,
    - Specific positioning instructions : orientation, settings…
  - Easy to understand, easy to install, easy to test



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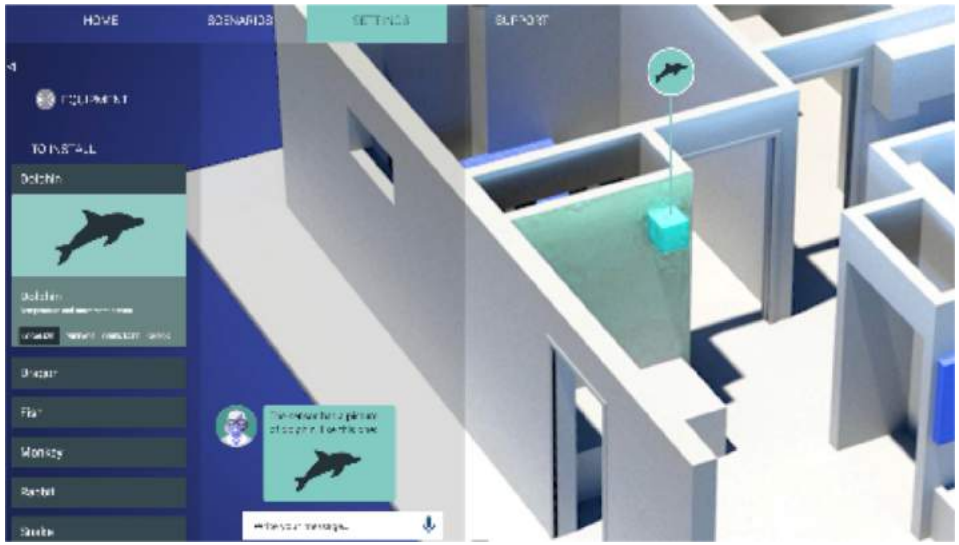
Design:
A blueprint for Night Wandering

- Wake up at night
  - Movement detector (over bed)
  - Pressure rug (on side of the bed)
  - Load sensors (under bed's structure)
- Going to bathroom
  - Lightpath (hallway)
  - Contact sensor (bathroom door)
  - Movement detector (oriented towards bathroom door)
  - Flowmeter (toilet pipe)
- Go to sleeping room
  - Same as « Wake up at night »
- Go to bed
  - Same as « Wake up at night »

Installation

- Box
  - Tag sensors to know where they have to be installed

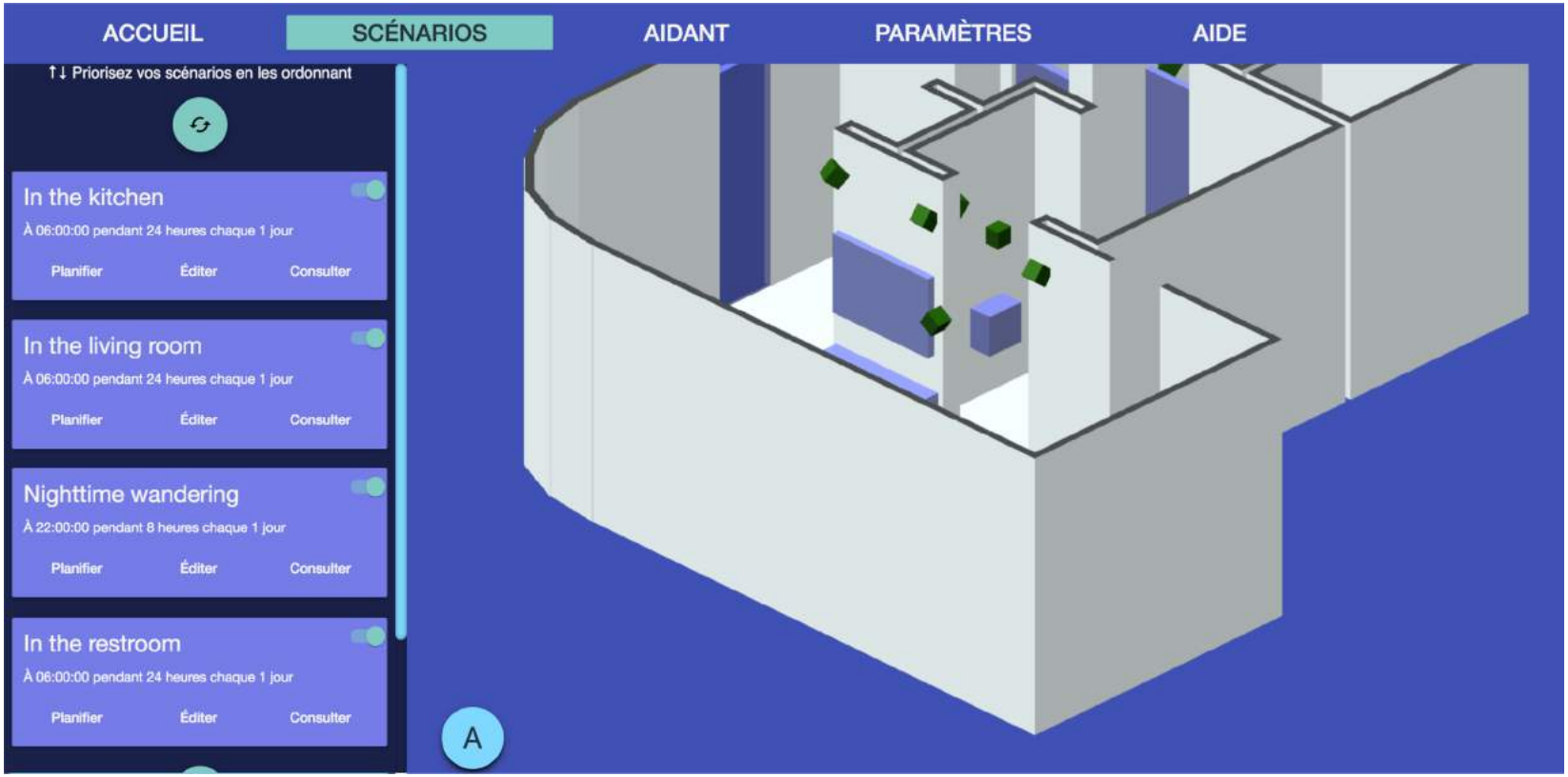


  - Augmented reality

- Test and fine-tune
  - « go in the bathroom and flush the toilet »

Use

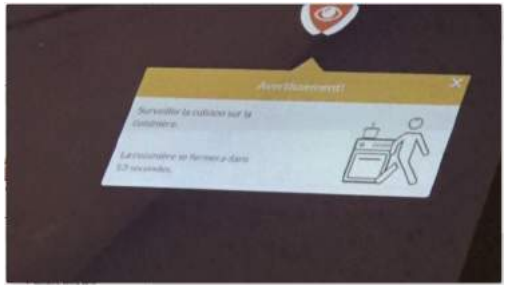
- Activate/deactivate scenarios



Use

- Cognitive assistance
  - Night wandering
  - Autonomous safety system

No one is watching the stove while something is cooking



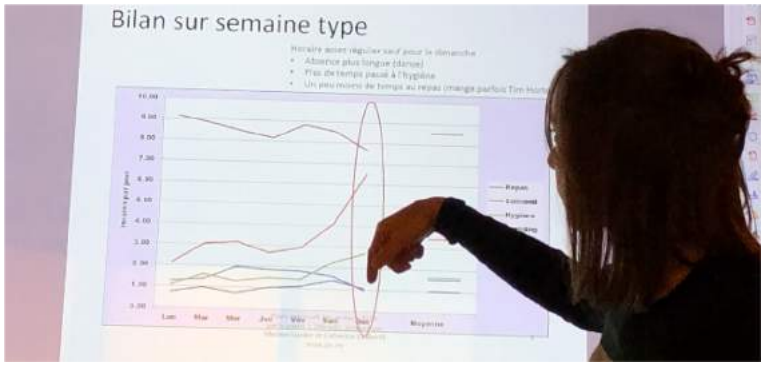
After 3 minutes, warning message

After 5 minutes, shutoff the stove and explain why

Use

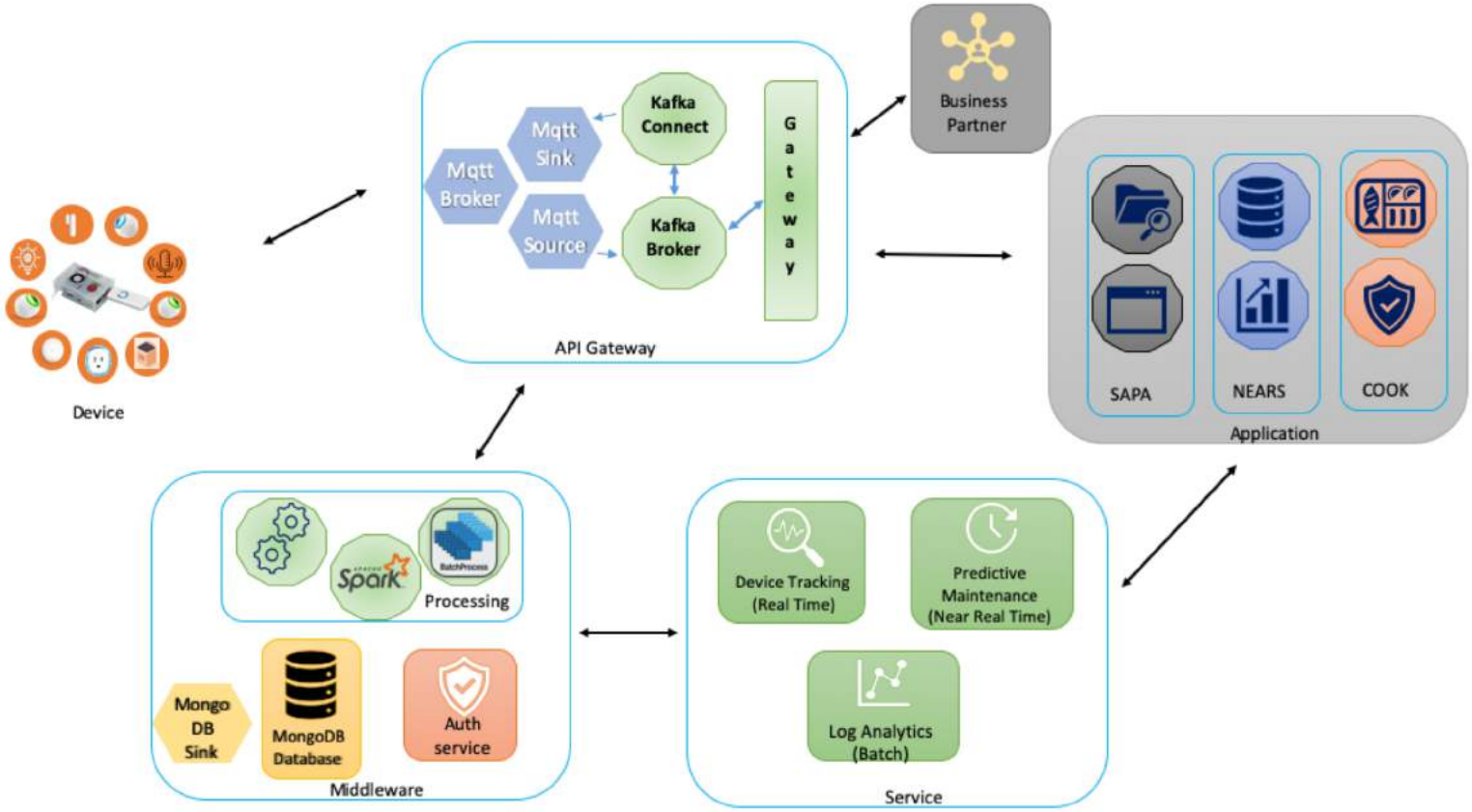
- Monitoring
  - Short time scale
    - Notifications, warning, alarms
    - Sensor states / on-going activity
      - Is the stove open now ?
      - Is my mother cooking now ?

  - Long time scale
    - Reporting
      - Has the person eaten this week?
      - Is the person active enough ?



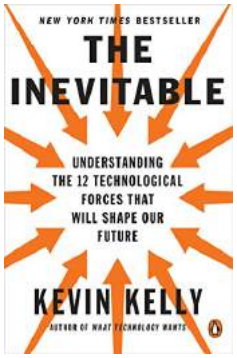
- Maintenance
  - Self-healing

Infrastructure and services



Benefits

- Co-creation of scenarios
  - Customizable packaged care ready scenarios
  - Brand new ones
- Iot Infrastructure
  - Easy to deploy
  - Expandable
  - Tools for test and maintenance
- Telemonitoring and assistance
  - Autonomy
  - Staying at home
  - Peace of mind for caregivers



Trends

- *Cognifying*
  - AI as ubiquitous as easily available as electricity
  - Integration of many AI technologies
- *Interacting*
  - Internet of things
  - « Architecture that sense and responds » Carlos Ratti
- *Tracking*
  - Giving semantic to raw data
- *Screening*
  - Smoothly interacting through the environment
  - Mixed reality
- *Sharing*
  - DIY
  - Sharing scenarios

Conclusion

- Do it yourself
  - a smart-home solution that is customisable by end-users
- Empowering the user
  - user-guided specification of the design requirements of sensors and actuators
  - allow user access to powerful sensing and automated reasoning algorithms through simple and easily customizable devices
  - Putting professional caregivers at the periphery
- AI-assisted
  - Internet of things
  - Ontologies, context awareness, ambient intelligence. **Data with meaning**.
  - Learning, **activity recognition, activity analysis**
  - Advanced UI (avatar, speech-recognition, **mixed reality**)
- Sharing experiences and solutions through scenarios
  - Social networks / on-line communities / sharing / crowdsourcing