

# Interaction in Cognitive IoT

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# Introduction

## A new RTO

The Luxembourg Institute of Science and Technology (LIST) is an emerging Research and Technology Organization (RTO) active in the fields of materials, the environment and IT.

Created in 2015 from the merger of two former Public Research Centres (CRP Gabriel Lippmann and CRP Henri Tudor), LIST brings together a critical mass of researchers and innovation experts to develop innovative and competitive solutions in response to the key needs of Luxembourgish and European companies.

### Human resources

- 592 collaborators of which 74% are researchers (65% men, 35% women)
- 79 Ph.D students
- 40 nationalities represented

### Research outcomes

- About 200 scientific publications with an impact factor = or > to 2 per year
- 26 filed patents and 13 paying licences in 2017



# AGENDA

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- What is Cognitive IoT
- What is a Thing
- Research areas & research questions
- Human-Thing Interaction
- Human modelling
- User Experience

Definition: Collective Artificial Intelligence for distributed reasoning and decision-making in smart environments.

The Internet of the future integrates technologies which emulate the **cognitive abilities of humans** – our perceptions as informed by all the senses; our awareness, imagination, and memory; our ability to plan, to orient ourselves, and to learn. It forms a network of cognitive technologies, and thereby is becoming a **Cognitive Internet**.

(Eckert: <https://ercim-news.ercim.eu/en119/keynote/cognitive-is-the-new-smart>).

# Our research

## Human Agent and Human-Thing Interaction

Investigate the role of the human factor in CloT:

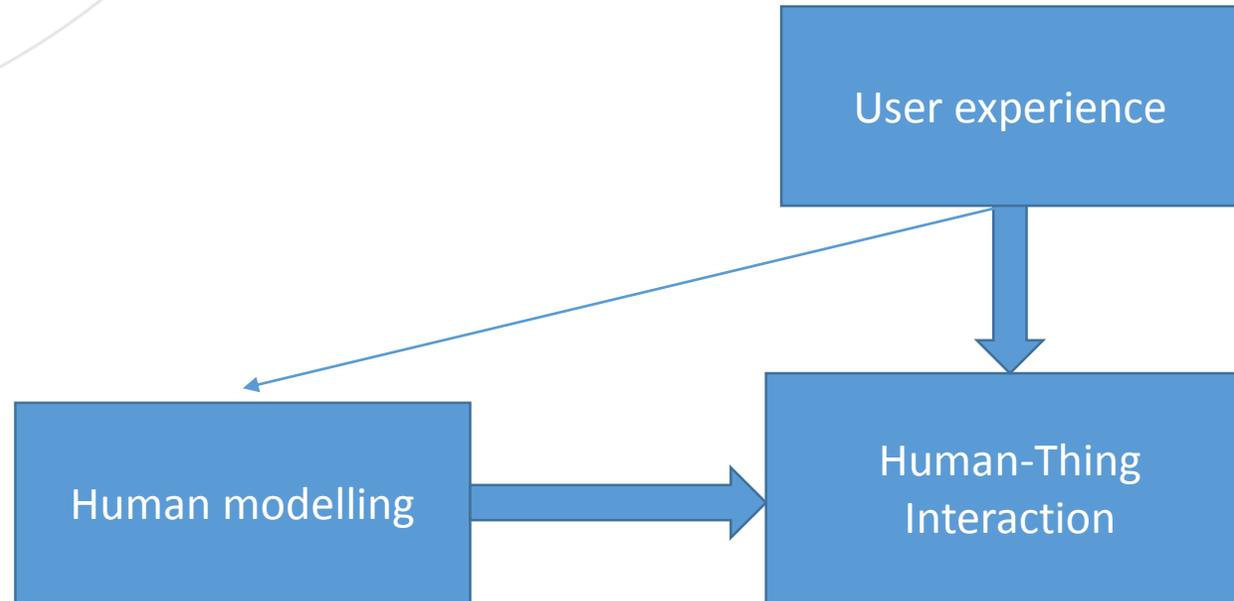
- Human Agent model
- Behaviour and specificities
- Human-Thing interaction models

### Research Question:

- How does a human user interact with Things in Cognitive IoT? Now and in the long-run?

# Research work areas

Human-Thing Interaction, Human modelling, User Experience



# What is a Thing

## Smart object are equal to Things in IoT

- What is a Thing?
  - How is a Thing designed?
  - How should be designed, so that the user has high-quality user experience?

Cena et al. (2019) defined the objects based on **the tight and seamless integration of a physical and a digital counterpart as "Smart Physical Objects" or SPOs**. They provided a framework singling out five abilities that can concur to define different forms and levels of smartness:

### 1. Cognitive abilities:

- i) knowledge management, i.e., the ability to maintain knowledge;
- ii) reasoning, i.e., the ability to make inferences;
- iii) learning, i.e. the ability to learn from experience;

### 2. Interaction abilities:

- iv) object-object interaction (OOI);
- v) human-object interaction (HOI).

# Thing design

- The physical object
- The software interface
- The hardware interface
  
- Interactions with other devices in the network
- Representation to other objects and human users

[Kuniavsky, 2010]

# Natural HCI

- Intelligent / Smart / Cognitive
- Tactile
- Touch-free (COVID-19)
- Implicit
- Personalized
- Pervasive
  
- Interaction modalities
  - Speech (authentication, multilingualism, pitch, volume)
  - Gaze
  - Posture (identification)
  - Haptics
  - Gesture (dynamic, continuous)
  - Brain-computer interfaces

# Embodied Conversational Agent (ECA)

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## Characteristics:

- attentive and adaptive;
  - trustful
  - expressive/communicative
  - socially interactive.
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- Different things provide different functionalities (e.g., microwave and printer), and might be of interest to different groups of people.
  - In case the user is not confident with or inconvenient with following up the interaction, then the cognitive thing should sense that and move from an implicit to explicit interaction mode.

# Human modelling

## BDI as a key starting point

- Human modeling: active question since decades (Bratman, 1987 for BDI), multidisciplinary topic
  - The most convenient and open way to define cognitive and human models is related to the BDI theory or architecture
  - BDI architecture and its several variants are the most used software architectures for intelligent agents because of its **simplicity** and **robustness**.
  - Three fundamental mental attitudes:
    1. **beliefs** (true or false information about the environment and oneself),
    2. **desires** (motivational state of the agent)
    3. and **intentions** (actions plans that have been selected and are committed to achieve and that provide the deliberative character to the model). (Sanchez-Lopez & Cerezo, 2019)
- Our goal: select and design an operational model that will fit the cognitive IoT prerequisites

## Challenges related to our BDI variant that fits with IOT needs

- Examples of challenges related to BDI modelling (cf. Sanchez.Lopez and Cerezo, 2019)
  - How emotions might influence all the BDI phases is still to be defined;
  - If innate or primary emotions (e.g. love) and secondary emotions (e.g. affection) are well defined, work is still needed for tertiary emotions (emotion which is a consequence of a secondary emotion. e.g. tenderness);
  - If there is personality theory which provides consensus (BIG 5), the influence of personality traits on cognitive and affective processes still needs additional work.
- **We plan to cover the full spectrum of affective and emotional components of human users or agents and their interdependencies.**
  - Mood, personality, emotions, regulation processes and feedback loops, in a dynamic situation, are a small excerpt of our future challenges and variables to consider.

- How to **design** a CloT Thing or System to have a good UX for end-users?
- How to **evaluate** the UX of a CloT Thing or System?

# 1. How to design a CloT Thing or System to have a good UX for end-users?

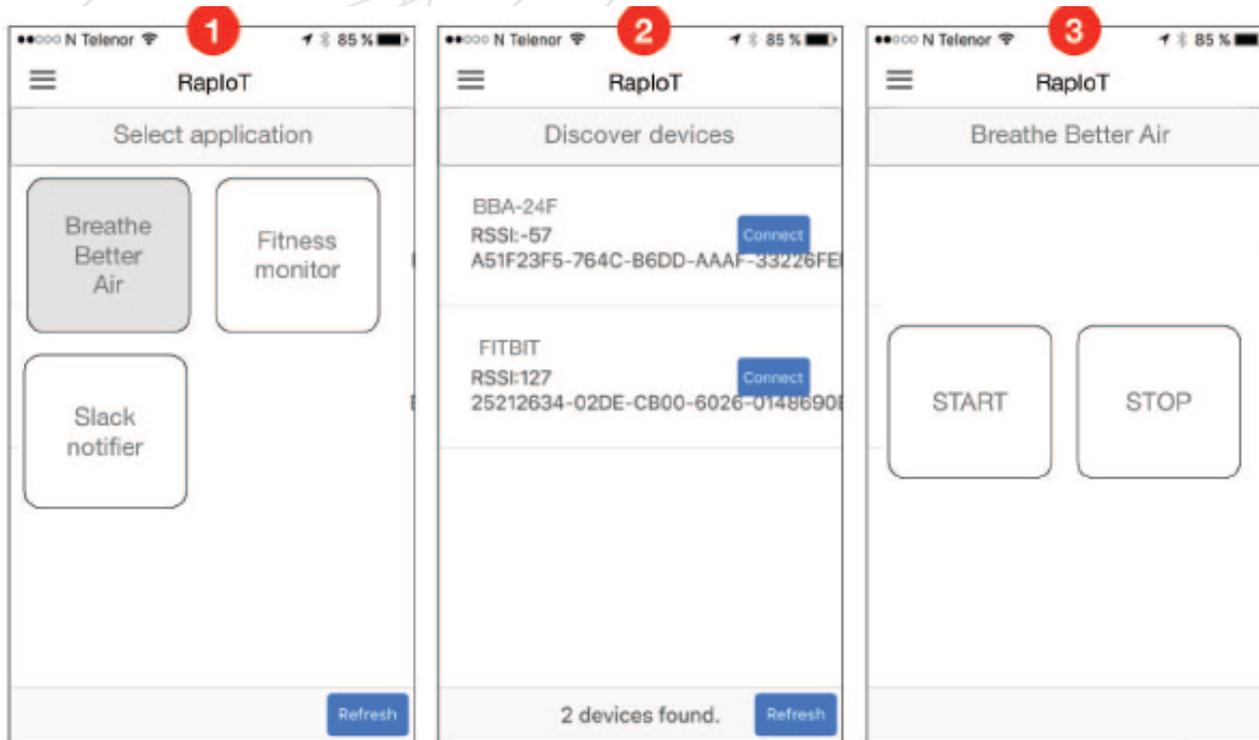


Figure 5. RapMobile Application

- PAwEn (People-Aware Environment) process to design IoT: combination of Design Thinking and User Centered Design process (Fauquex et al.)
- Seven design toolkits to support the discovery of IoT, ideation and the analysis of the context (Kurze et al.)
- RapIoT Toolkit enables the rapid prototyping of IoT systems (Gianni et al.)

- Fauquex et al. 2015. *Creating people-aware IoT applications by combining design thinking and user-centered design methods.*
- Gianni et al. 2019. *RapIoT toolkit: Rapid prototyping of collaborative Internet of Things applications*
- Kurze et al. 2019. *A Collaborative Landscaping Exercise of IoT Design Methods*

## 2. How to evaluate the UX of a CloT Thing or System?

Done mainly thanks to well-known UX methods, but also:

- Stimulates the IoT system thanks to Virtual Reality and the Wizard of Oz method [1]
- Use of tracing data during usage of Things in the real world, by real users in their real context [22, 14]
- Lot of studies use the NASA-TLX questionnaire [12] to evaluate workload of IoT [1-4, 7]
- Quality of Experience model [23]
- Technology Acceptance Model [20]

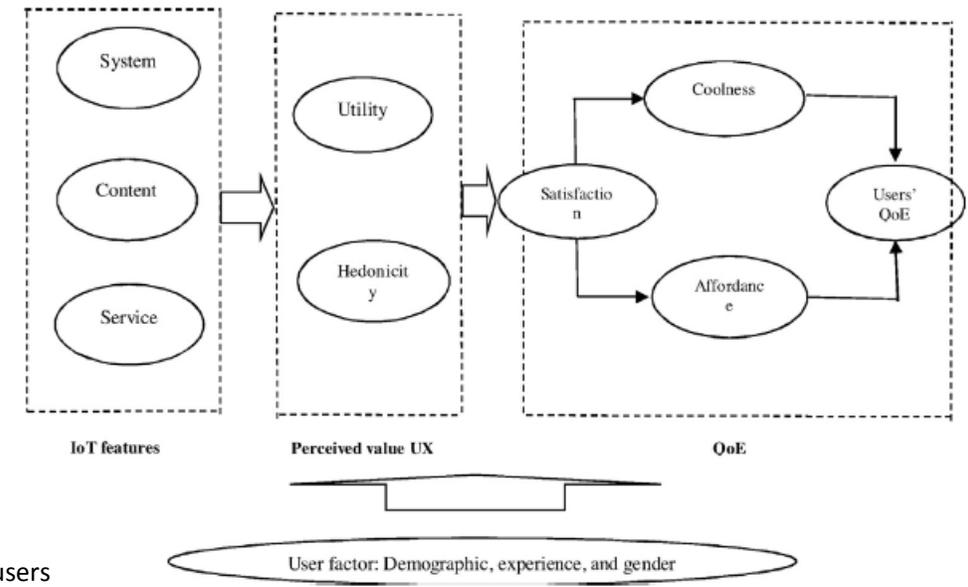
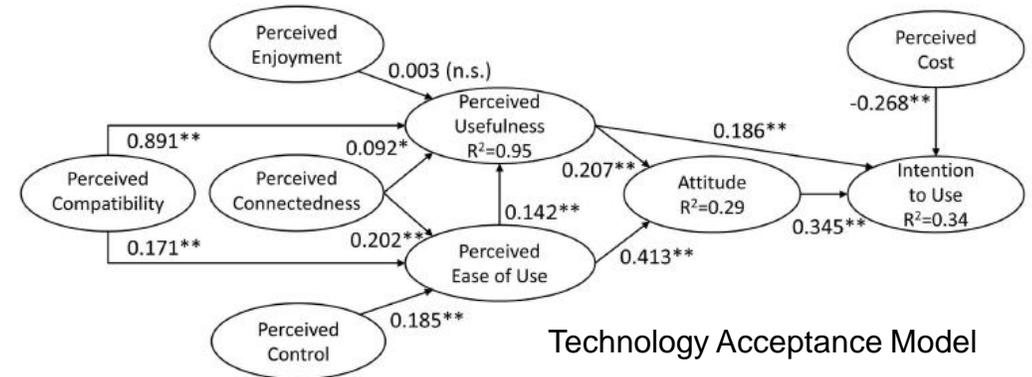


Fig. 1. QoE model for personal informatics.

[1] Alce et al. Design and Evaluation of Three Interaction Models for Manipulating Internet of Things (IoT) Devices in Virtual Reality

[2] Alce et al. UbiCompass: An IoT Interaction Concept.

[3] Amato et al. SNOPS: a smart environment for cultural heritage applications

[4] Ardito et al. Analysing trade-offs in frameworks for the design of smart environments

[7] Chiu et al. Develop a personalized intelligent music selection system based on heart rate variability and machine learning

[12] Hart et al. NASA-task load index (NASA-TLX); 20 years later

[14] Kim et al. Revealing household characteristics using connected home products

[20] Park et al. Comprehensive approaches to user acceptance of Internet of Things in a smart home environment.

[22] Sciuto et al. Hey Alexa, What's Up?" A Mixed-Methods Studies of In-Home Conversational Agent Usage

[23] Shin et al. Conceptualizing and measuring quality of experience of the internet of things: Exploring how quality is perceived by users

# Our research challenges

- Definitions of CloT and Thing
- **Natural** Human-Thing Interaction and its interaction modalities
- Full spectrum of **affective and emotional components** of human users or agents and their interdependencies (beyond BDI).
- Evaluation of UX of Things should be done considering the **CloT specificities** (beyond well-known UX methods).

**Thank you for watching & listening!**

Interested in project proposals / partnership in Cognitive IoT?

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[www.list.lu](http://www.list.lu)