

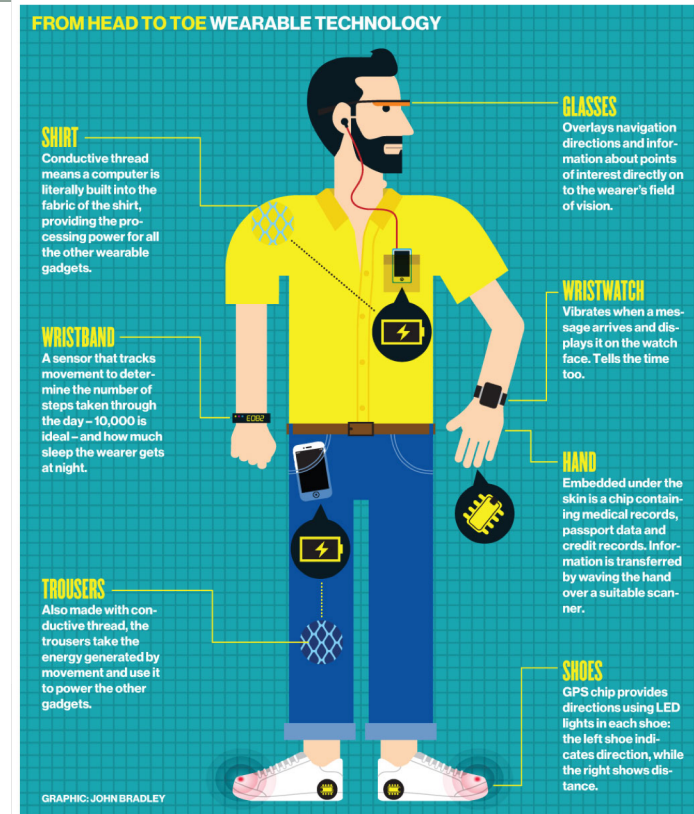
DISTRIBUTED SPEAKING OBJECTS: A CASE FOR MASSIVE MULTIAGENT SYSTEMS

Franco Zambonelli, Marco Lippi, Marco Mamei, Stefano Mariani
Università di Modena e Reggio Emilia



General Scenario

- IoT explosion
 - Tens of devices on each person and room
 - Thousands in each building
 - Millions in cities
 - Billions nationwide
- To control and regulate each and every aspects of our everyday life
- Cities management, mobility, healthcare, entertainment



Hospital Management

- Large-scale hospital
 - Recovery rooms
 - Surgery & Rehabilitation rooms
- Individual monitoring and actions
 - Bio-sensors & Activity Sensors for patients
 - Recommender systems
- Room monitoring and automated room settings
 - E.g., curtain control and bed control for recovery rooms
- Overall control of hospital conditions
 - Energy, temperature, occupation, emergency management

Vargiu, et al: Integrated Care for Complex Chronic Patients.
International Journal of Integrated Care, 2017



Massive Scale

- High-number of (software defined) components
 - Mobile, ephemeral, unreliable, unidentifiable
- Part of a very large-scale system (system of systems)
 - Need to engineer coordinated local behaviours
 - E.g., the devices to regulate rooms temperature
 - Need to ensure global outcomes
 - E.g., overall energy consumption
- Local coordination impact global behaviours

Omicini & Zambonelli: Challenges of decentralized coordination in large-scale ubicomp systems. UbiComp Adjunct 2016: 1315-1320

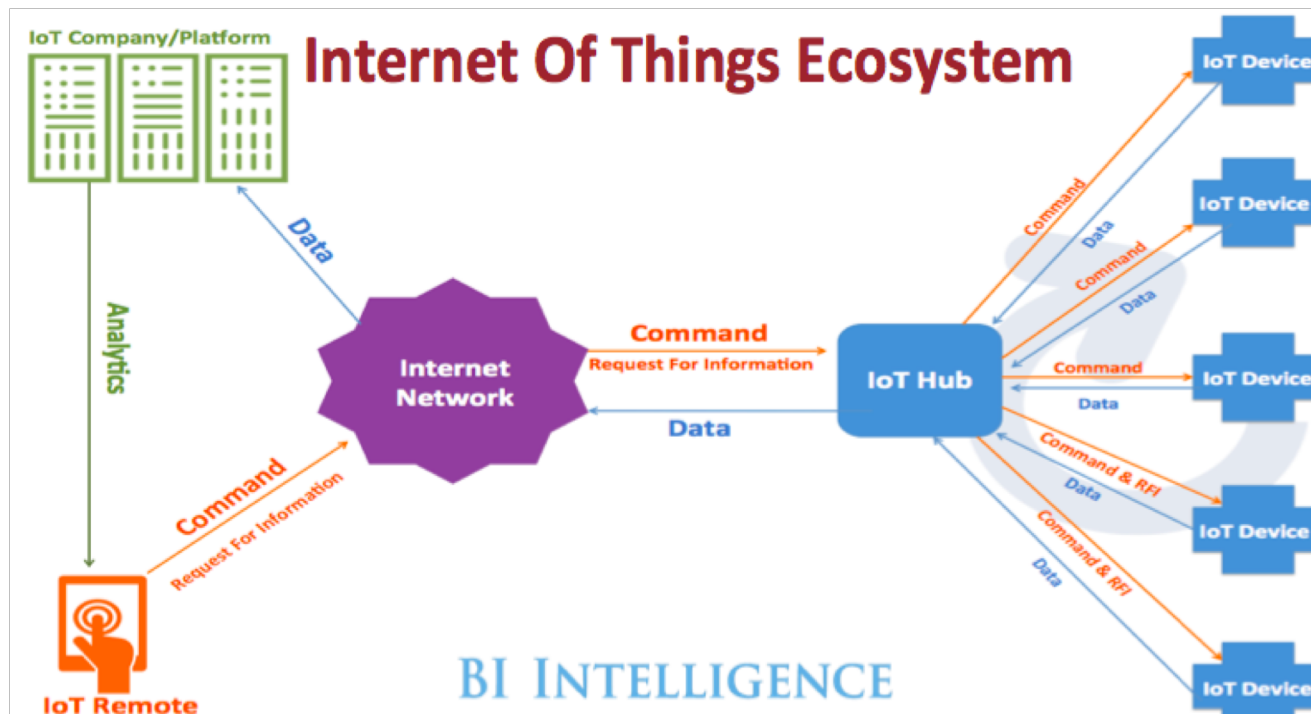


Coordinating What?

- What are the devices to be coordinated?
- Most current IoT approaches focuses on simple IoT devices
 - Service-oriented and providing resources and/or receiving commands
 - Simple sensors and actuators
- This does not take into account the emergence of autonomous components
 - Proactive in charge of achieving goals
 - Self-driving vehicles, personal assistants
- And the fact that humans are an inherent part of the picture
 - And are to be dynamically involved in the functioning of the IoT system

Coordinating How?

- Mostly centralized or semi-decentralized architecture
- Based on static coordination schemes

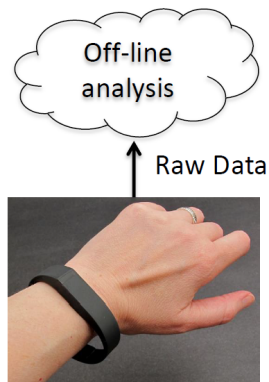


From IoT Devices to “Speaking Objects”

- Today
 - **Sensors** producing raw data streams.
 - **Actuators** receiving basic commands
- Tomorrow
 - **Smart sensors** use machine learning and pattern analysis to produce high-level situational assertions
 - **Smart actuators** (becoming semi-autonomous) receiving “desires” and execute actions to fulfill them

Lippi, Mamei, Mariani, Zambonelli:
Coordinating Distributed Speaking
Objects. IEEE ICDCS 2017: 1949-
1960

Turn on light id:183



I want to watch a movie



From IoT Devices to “Speaking Objects”

- Today

- **Sensors** p
- **Actuator**

- Tomorrow

- **Smart se**
analysis t
- **Smart ac**
receiving

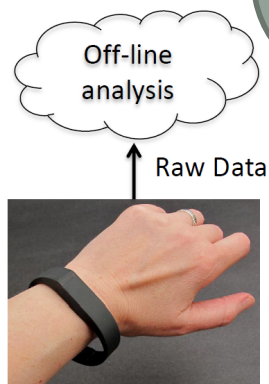
Lippi, Mamei, Mariani, Zambonelli:
Coordinating Distributed Speaking
Agents. IEEE ICDCS 2017: 1949-

DE FACTO SITUATED, AI-
POWERED, GOAL-ORIENTED
AGENTS!!!!

Turn on light id:183



I want to watch a movie



Interacting Speaking Objects

- **Interacting smart sensors** to promptly acquire more knowledge by fusing information with nearby devices
- **Interacting smart actuators** will coordinate activities to better fulfill high-level goals

Accelerometer: running +

GPS: indoor +

Microphone: background music =

Running on a tread mill



From Protocols to Argumentations

Lippi, Mamei, Mariani, Zambonelli: An argumentation-based perspective over the social IoT. IEEE IoT Journal, 2018, to appear.

- Speaking objects and autonomous entities will engage in conversations and can argue with each other.
- More **expressive arguments and assertions rather than a set of rules and protocols**
- Possibility to discuss and **dynamically change goals and plans**



A: Coming from north, need to go straight.

B: Coming from west, need to turn left.

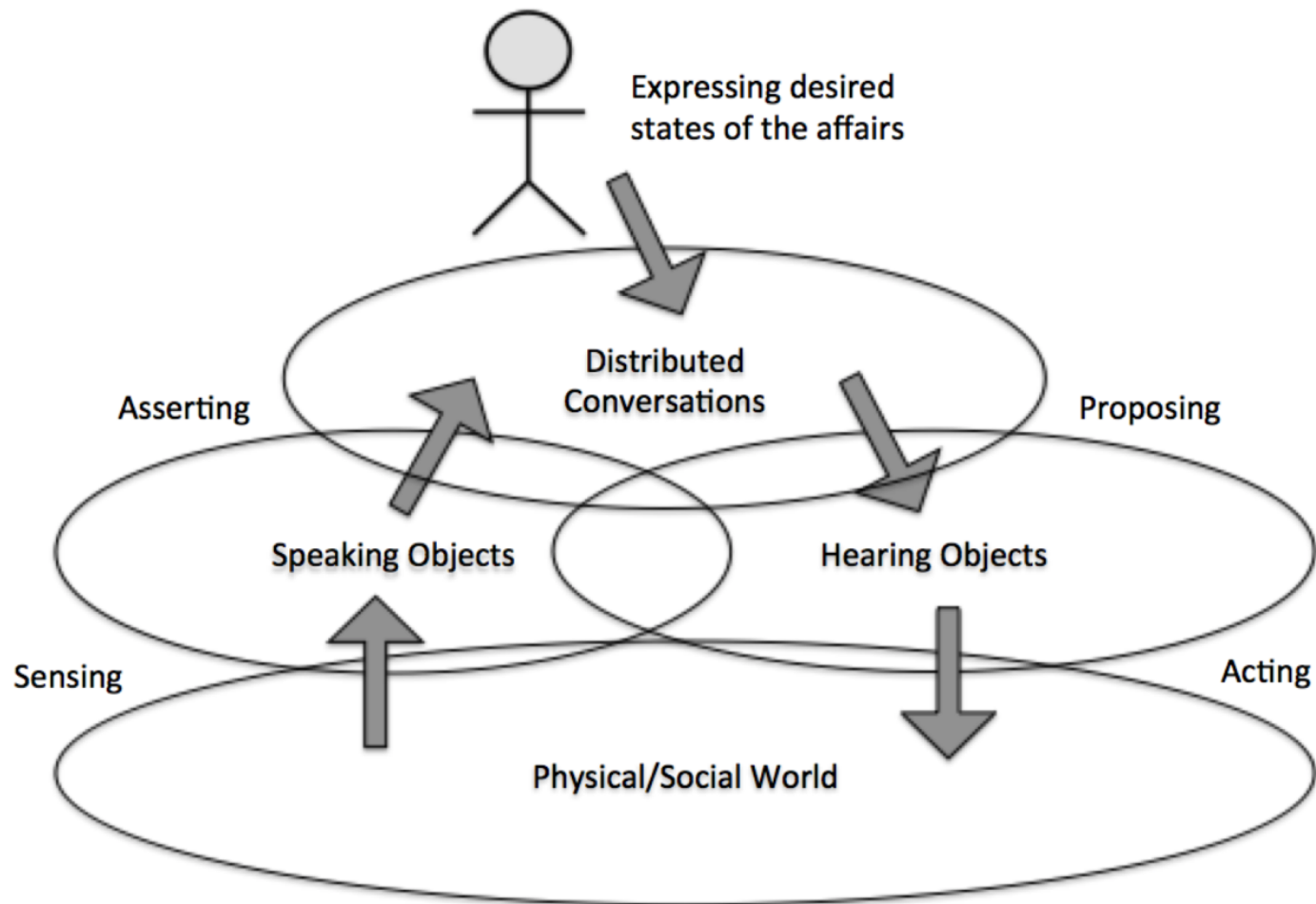
I: B would you go straight instead of waiting?

B: Sorry, I really need to turn left to reach home.

I: A would you turn right instead of waiting?

A: Yes that would bring me to destination anyway

The Overall Vision



Types of Conversations

- **Speaking sensors:** interact with each other in order to build and report a complete and coherent understanding of their surroundings
 - *Information Seeking and Inquiries*
 - *Persuasion*
- **Speaking actuators:** engage in deliberation dialogues, meant to achieve a shared plan by exchanging arguments about feasibility of actions, their expected utility, etc.
 - *Deliberation*
 - *Persuasion*

Example of Information Seeking Dialogue

- S smartphone, W wristband, C cameras

$is_1)$ S : Everybody listen, I'm detecting a clear coughing sound, should we worry?

$is_2)$ W : Probably yes, since the heart beat is accelerating steadily!

$is_3)$ C_i : Wait a minute, Walter was just eating peanuts a moment ago, could it be food choking instead?

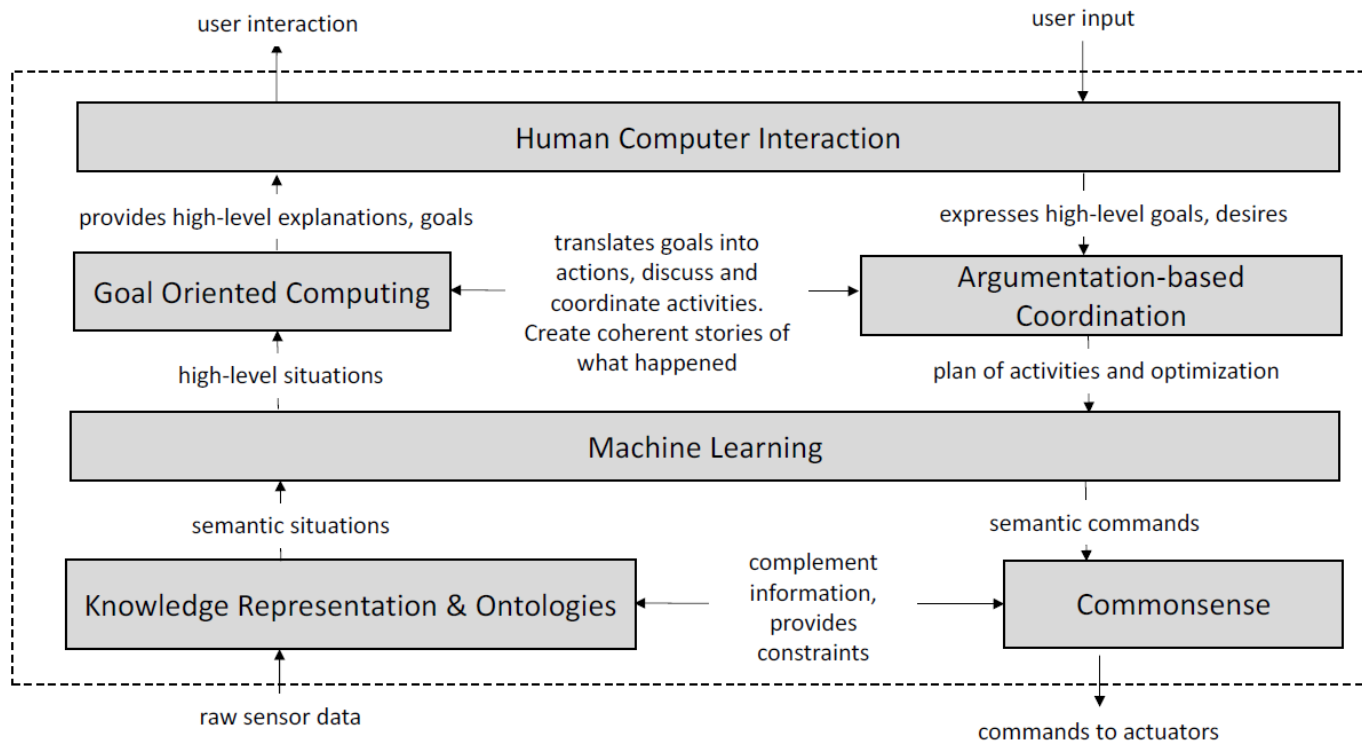
$is_4)$ C_j : I can confirm, he is now punching his own breast and trying to puke.

Example of Deliberation Dialogue

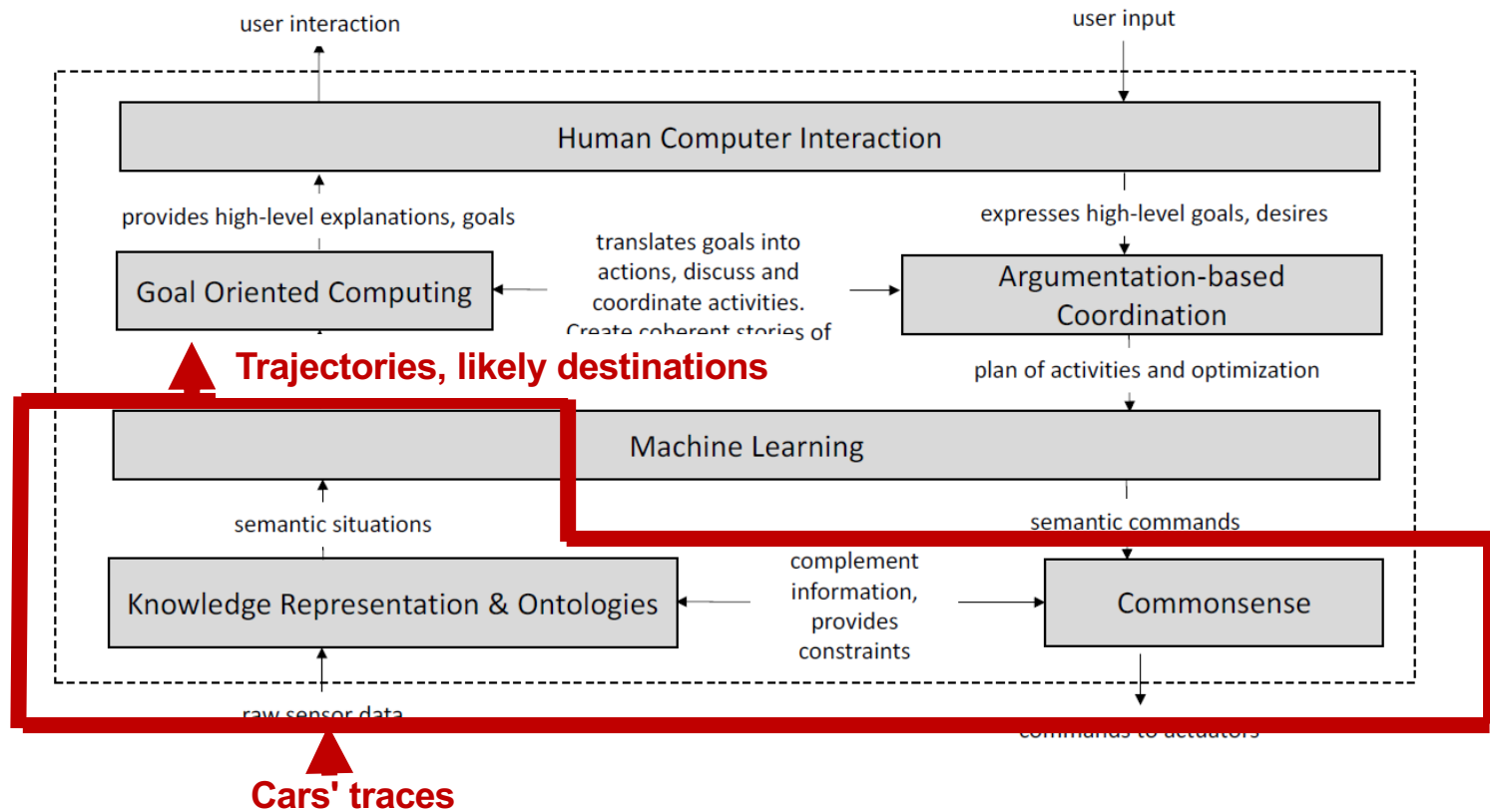
- S smartphone, C cameras, Wa smart watch, Ch wheelchair

d_1) S : Status report, please.
 d_2) C_j : He is not puking yet.
 d_3) S : I text Linda [*Walter's daughter*] to get here.
 d_4) Wa : You may try, but she's at the dentist now
thus she may not come in time!
 d_5) Ch : Go for it, I'll take Walter out in the
meanwhile.
 d_6) Ce_k : Agreed, there's a neighbour mowing the
lawn just across the road.
 d_7) S : I'll also call the ambulance.

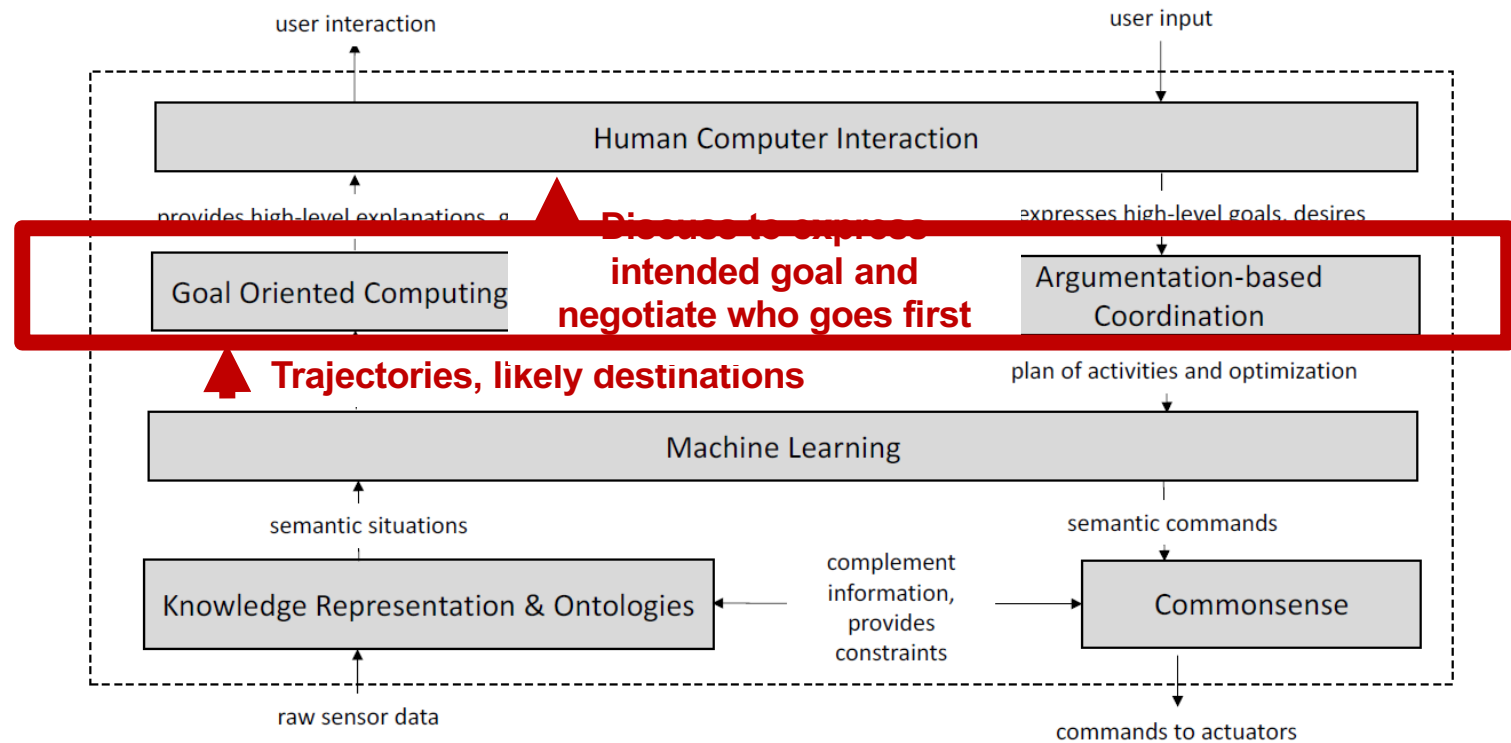
Key Technologies



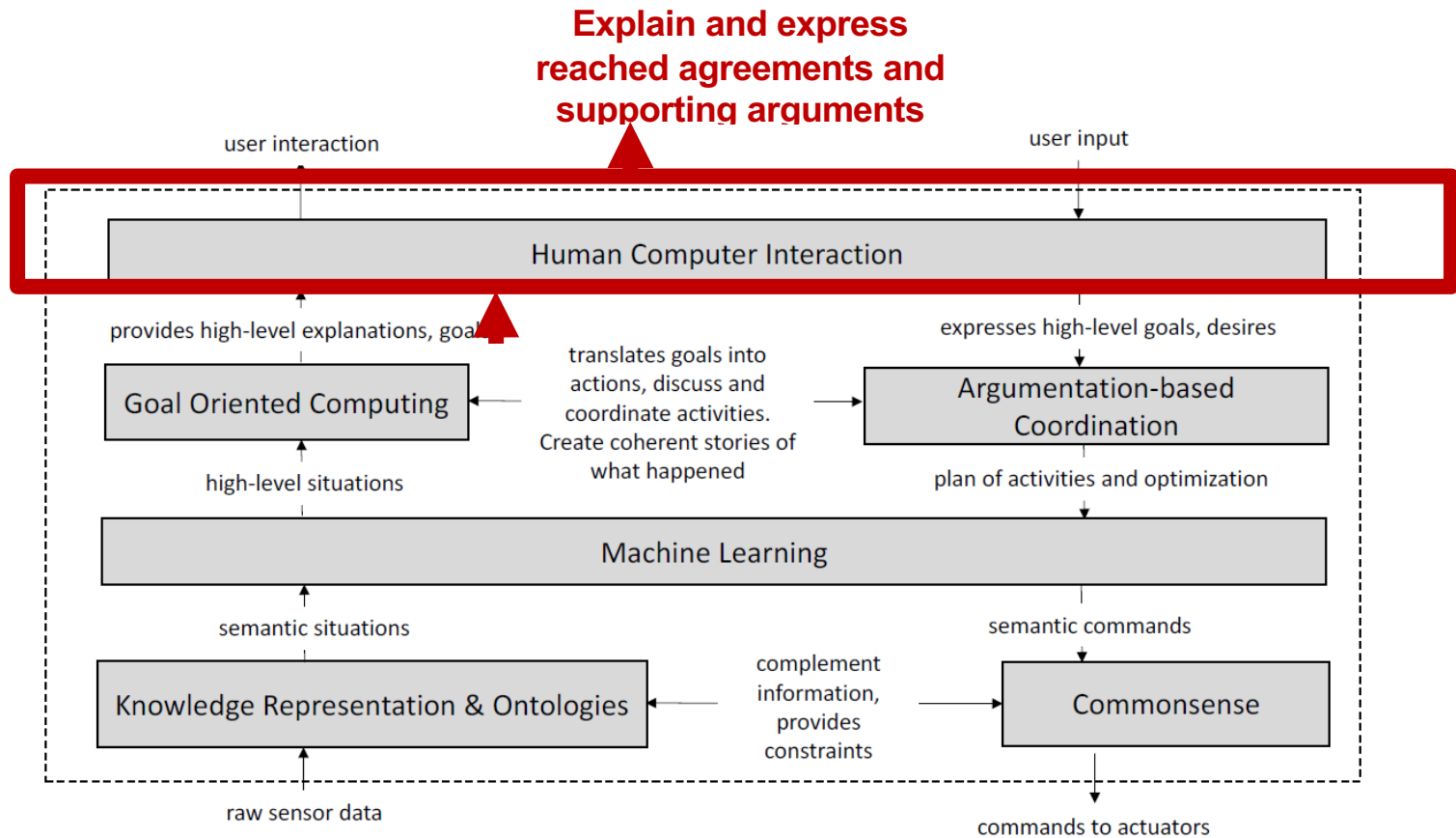
Key Technologies



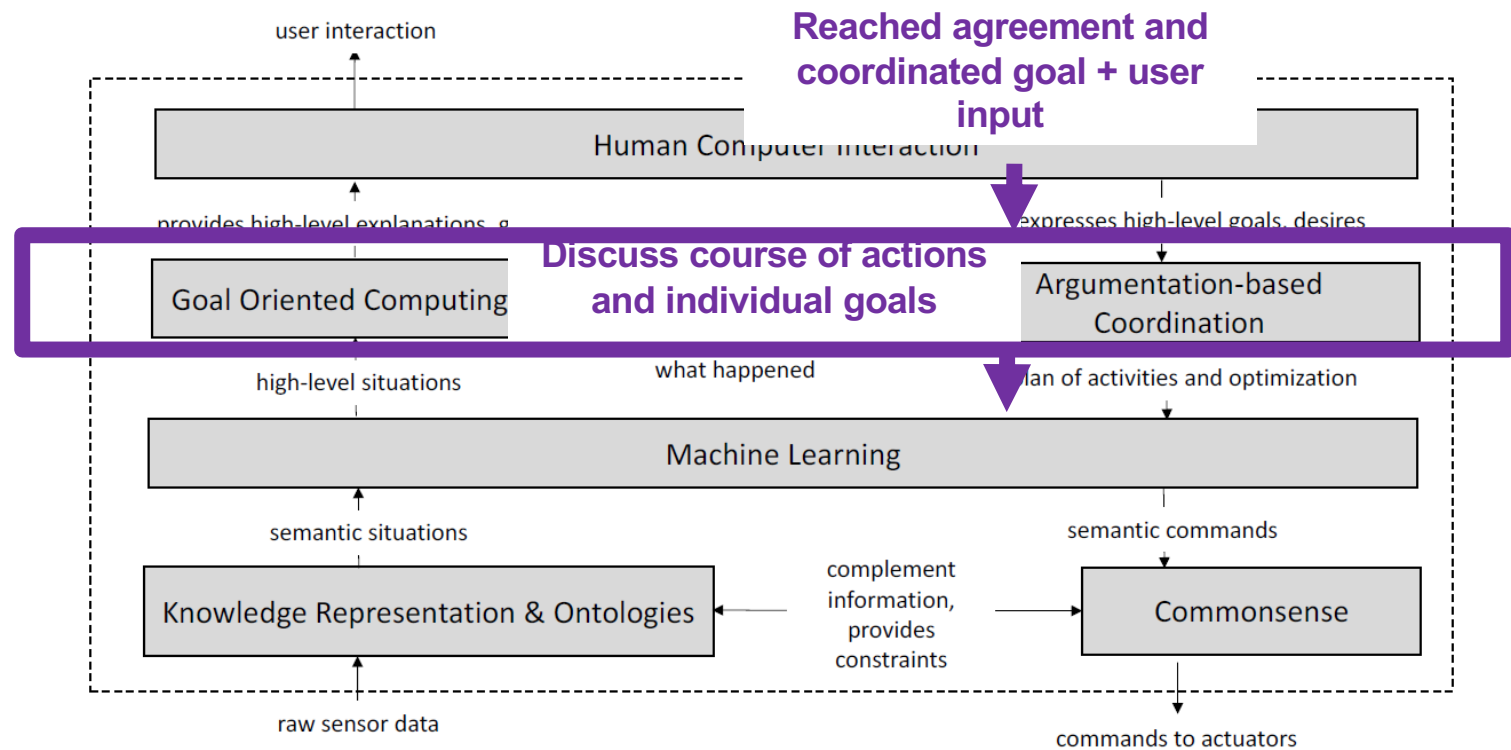
Key Technologies



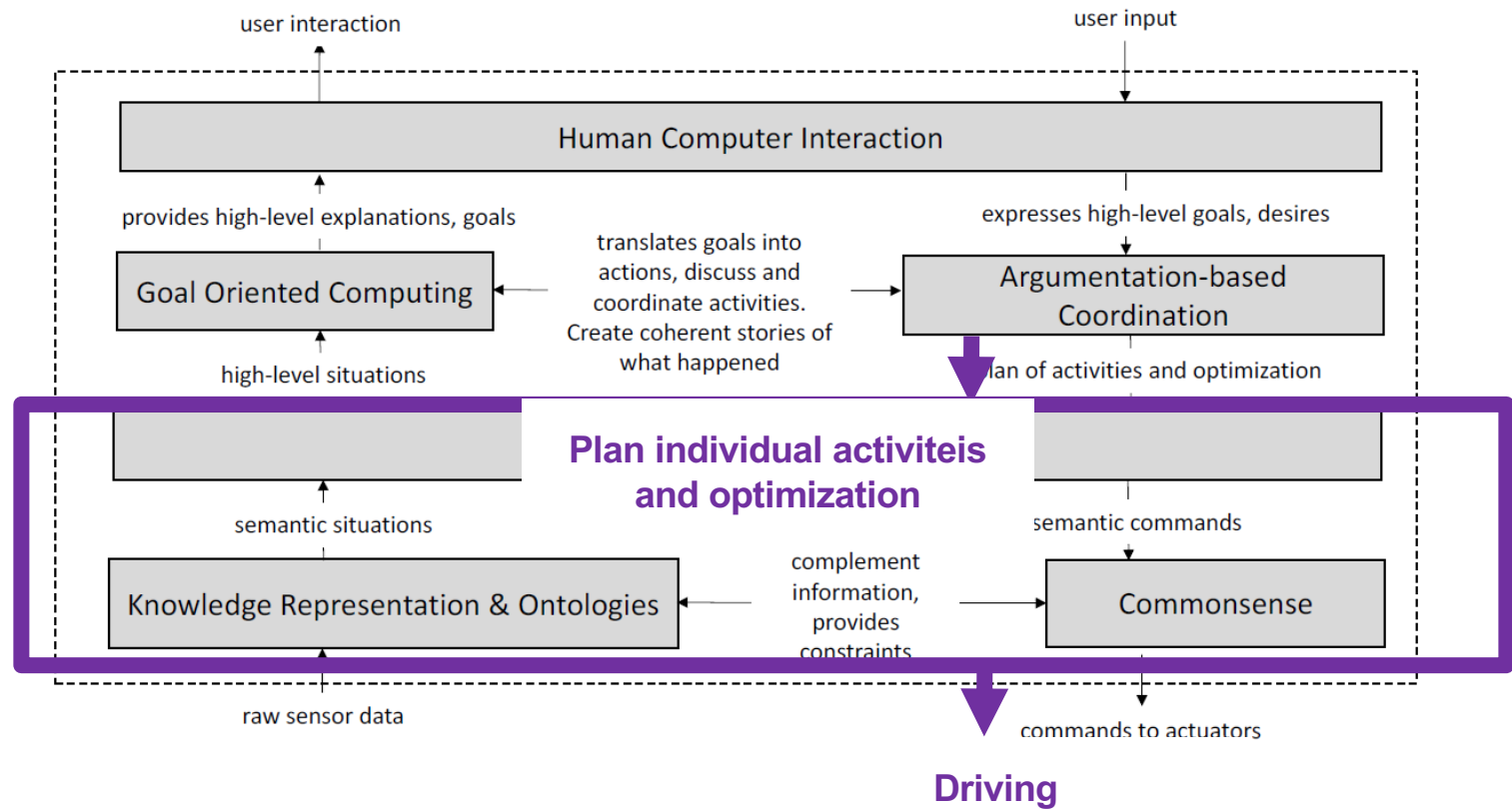
Key Technologies



Key Technologies



Key Technologies



Integration Challenges

- **Modeling, Engineering and Middleware**
 - Self-adaptive/self-organizing systems and agent-oriented software engineering
 - Support conversations via an open and shared conversation space
- **Humans in the Loop and Algocracy**
 - Socio-technical systems
 - The ability of smart objects to justify their stances, in fact, becomes crucial to convince users to effectively participate in the conversational process
- **Security**
 - By making speaking objects able to understand the reasons behind the evolution of a conversation and of the overall behavior of the system, objects may become capable of recognizing malicious behaviors and threats

Conclusions

- I have concluded
- Thanks!