

COACHES

COoperative Autonomous Robots in Complex and Human Environments



Coordinator : Abdel-Iliah Mouaddib

Partners : University of Caen Basse-Normandie, France

University of Sapienza Roma, Italy

Vrije Universiteit Brussel , Belgium

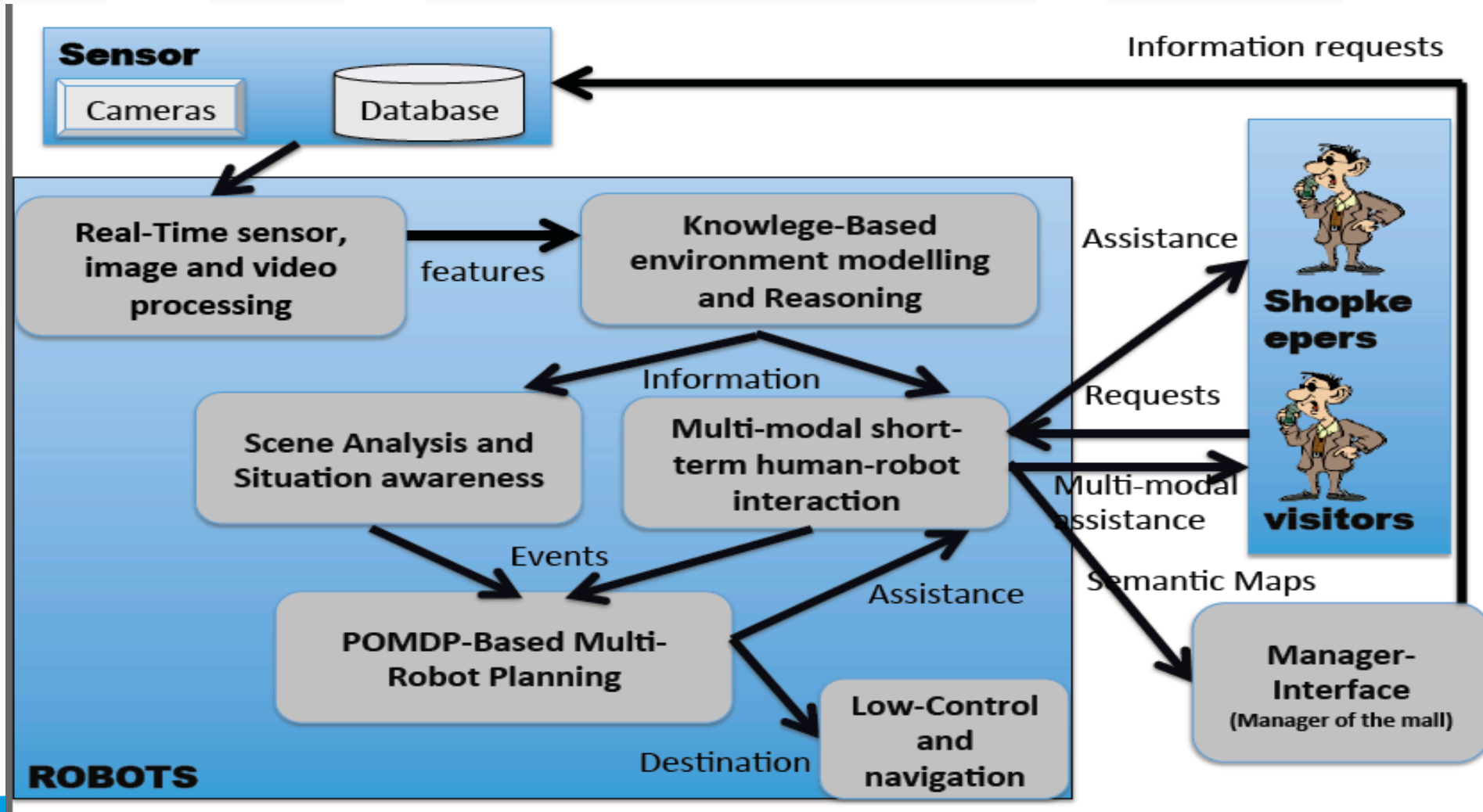
Sabancı University , Istanbul, Turkey

Participants: Agglomeration Caen la mer, Ville de Caen
Rive de L'orne Mall, Caen
SME Algorithmica, Italie



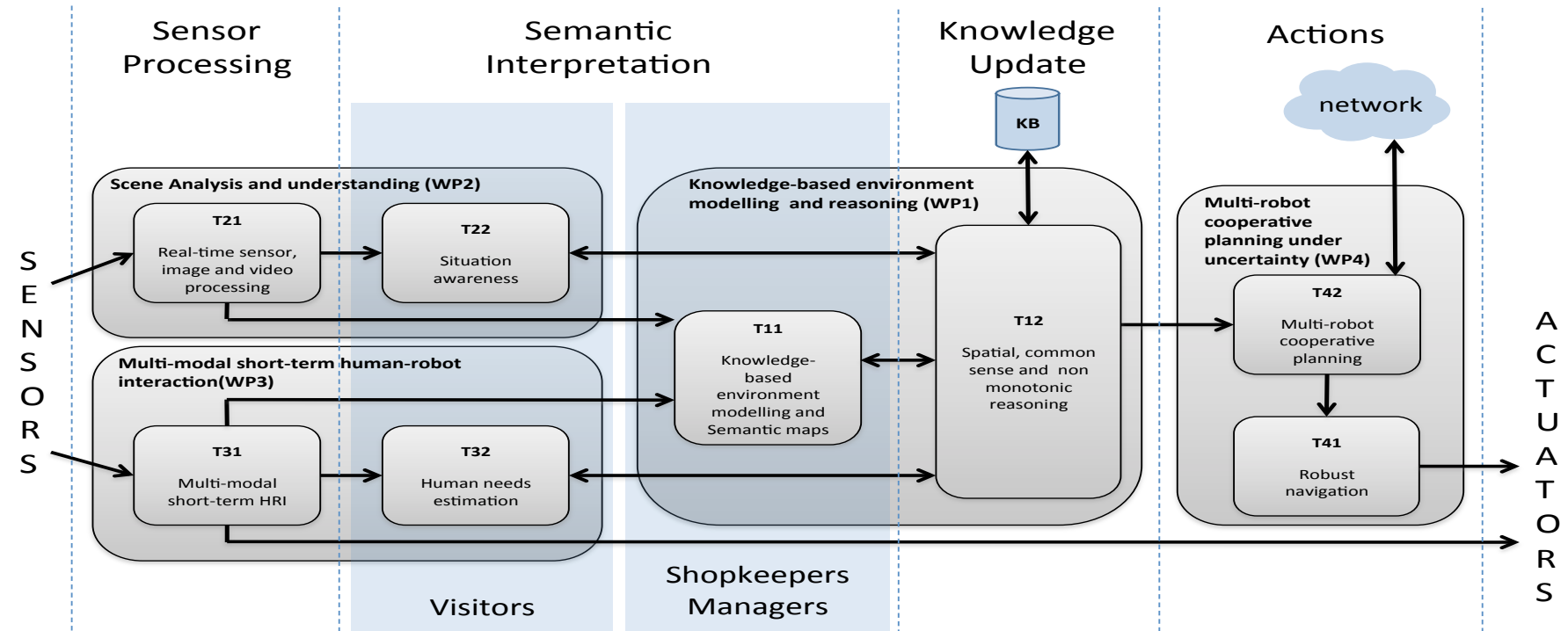
- Deploying robots in public areas to assist, guide, and escort visitors and surveillance
- Visual applications are born:
 - Guidance and Personal assistance in public areas
 - **Shop malls, touristic sites, airport, train stations, hospitals**
 - Surveillance and patrolling in cooperative way with intervention units (**firefighters, police, medical units, and tourist office staff, ...**)
- **Our target use cases:**
 - **Caen Rive de l'Orne Shopping Mall in cooperation with Caen city**

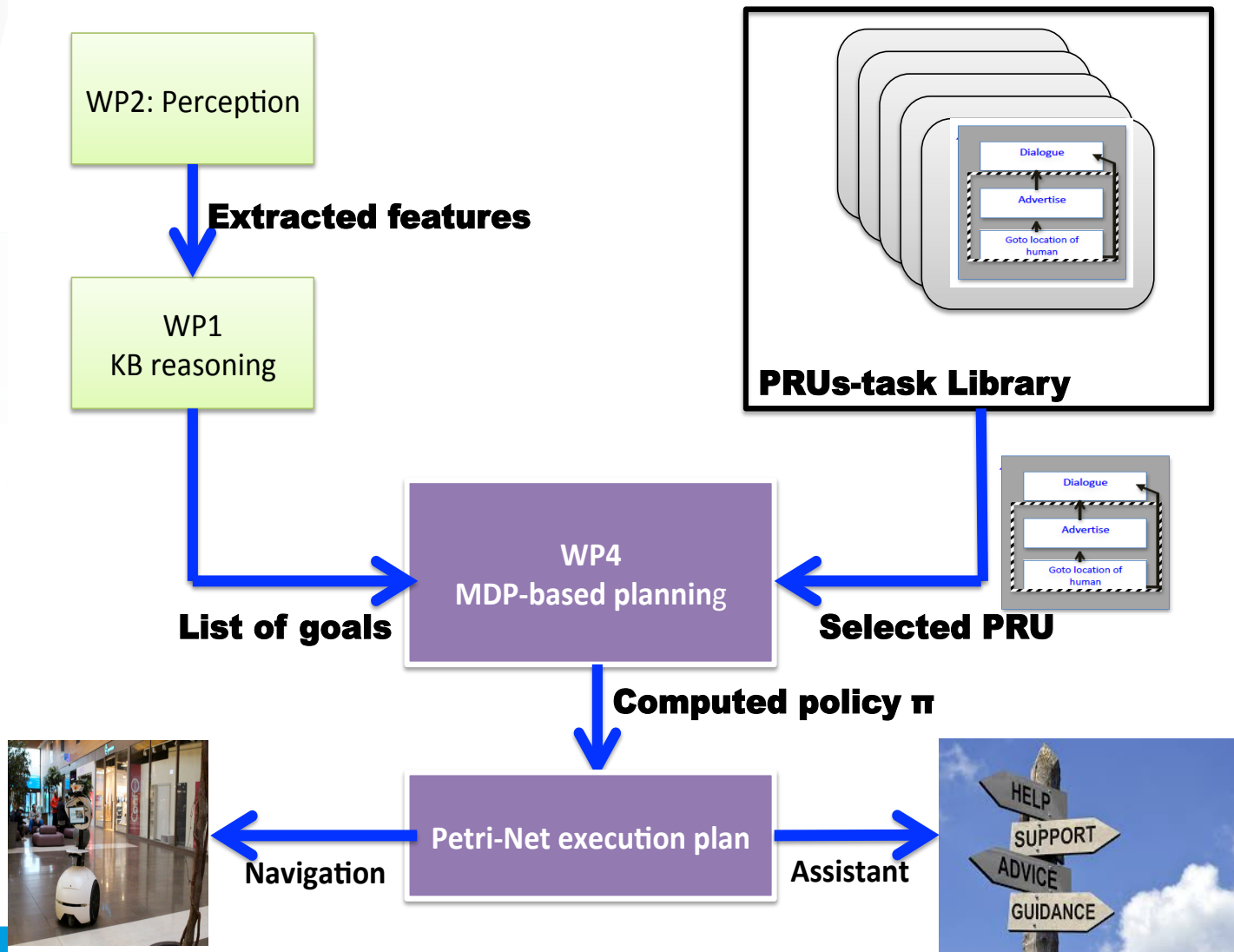
Architecture of the system



- **WP1: Environment modelling and Knowledge-based reasoning**
 - T11: Knowledge-based environment representation
 - T12: Commonsense and spatio-temporal reasoning
- **WP2: Image and Video processing**
 - T21: Image and video processing
 - T22: Situation awareness, activity recognition and abnormal events
- **WP3: Multi-modal short-terme human-robot interaction**
 - T31: multi-modal human-robot interface From robot to human and From human to robot
 - T32: Human needs estimation and information fusion
- **WP4: Multi-Robot cooperative planning and Robuste Navigation**
 - T41: Robust and safe Navigation in populated areas
 - T42: Goal-Based Interaction Decentralized Decision-Making for Multi-agent Planning
- **WP5: Soft and hard architecture, use cases and integration/validation**
 - T51: ROS-based Architecture
 - T52: Use cases definition
 - T53: Setup of the robots
 - T54: Demonstrations
 - T55: Performance evaluation

Software and data flow



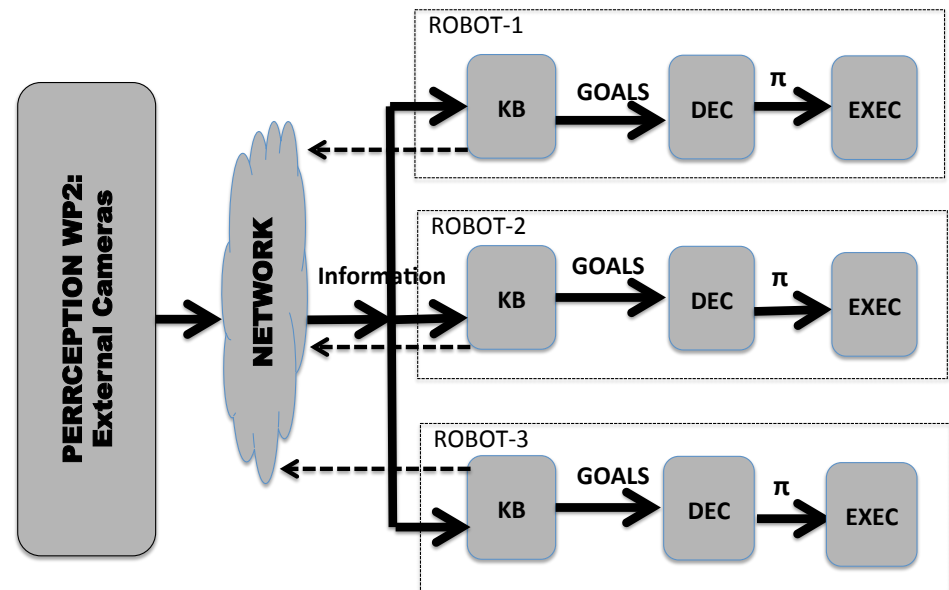


- Ability to
 - navigate in a crowded environment ;
 - detect people ;
 - interact with them ;
 - And, then to assist them
- Deployment in
 - A shopping mall
 - A center of congress
 - A hospital
 - IAB Forum,



- Objectives :
 - Extending the **system to multi-robots**
 - Extending perception to on-board cameras
 - **Face detection**
 - **People detection and tracking**
 - Developing an **escort method**
 - Improving the **interaction interface** to be more simple and intuitive

- **T41: Robust Navigation**
(delivered)
- **T42: Multi-robot architecture and planning**
 - Distributed MDP planning
 - Augmented MDPs
 - Distributed reasoning :
Multiple TEMP KB reasoning

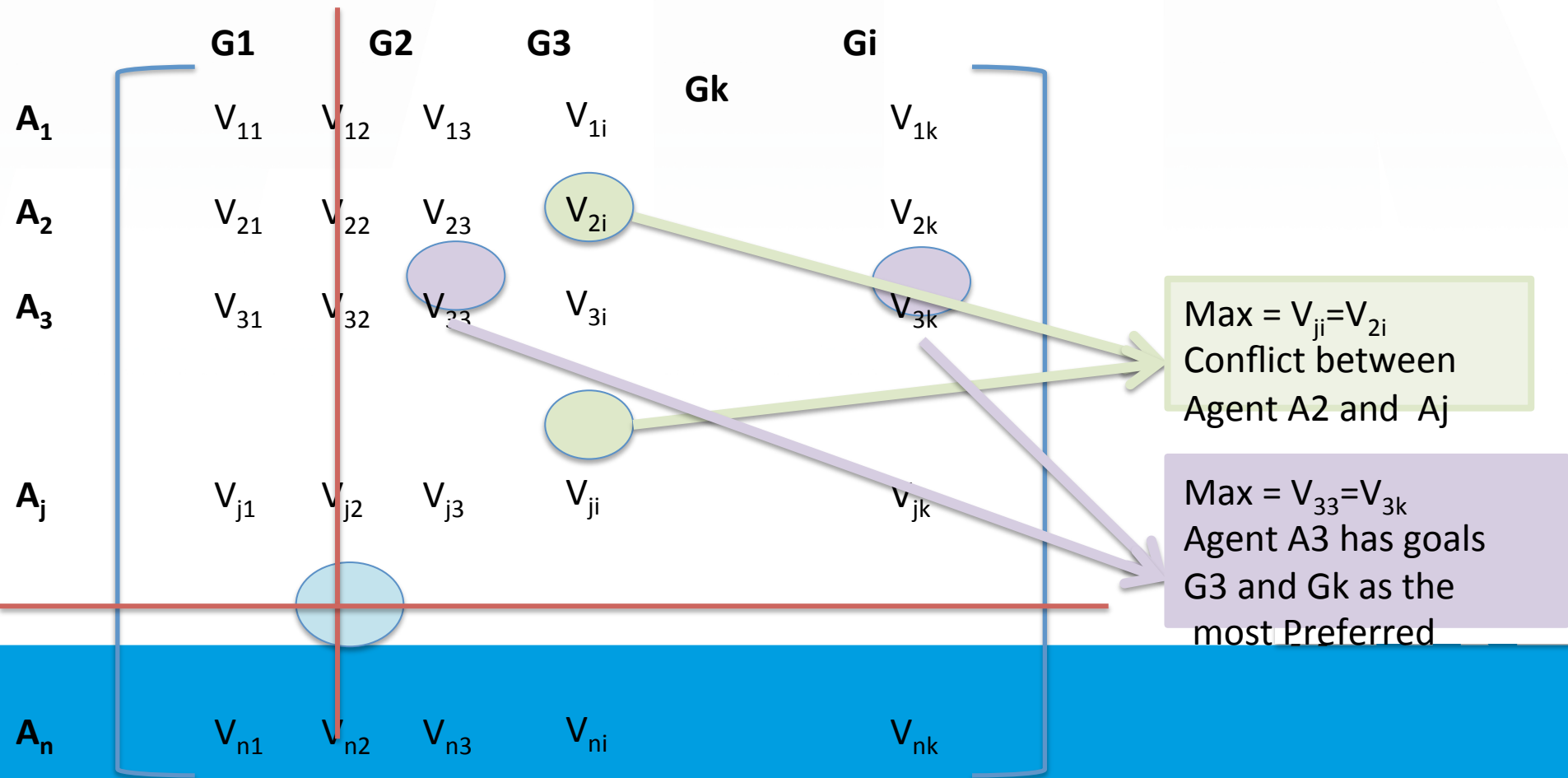


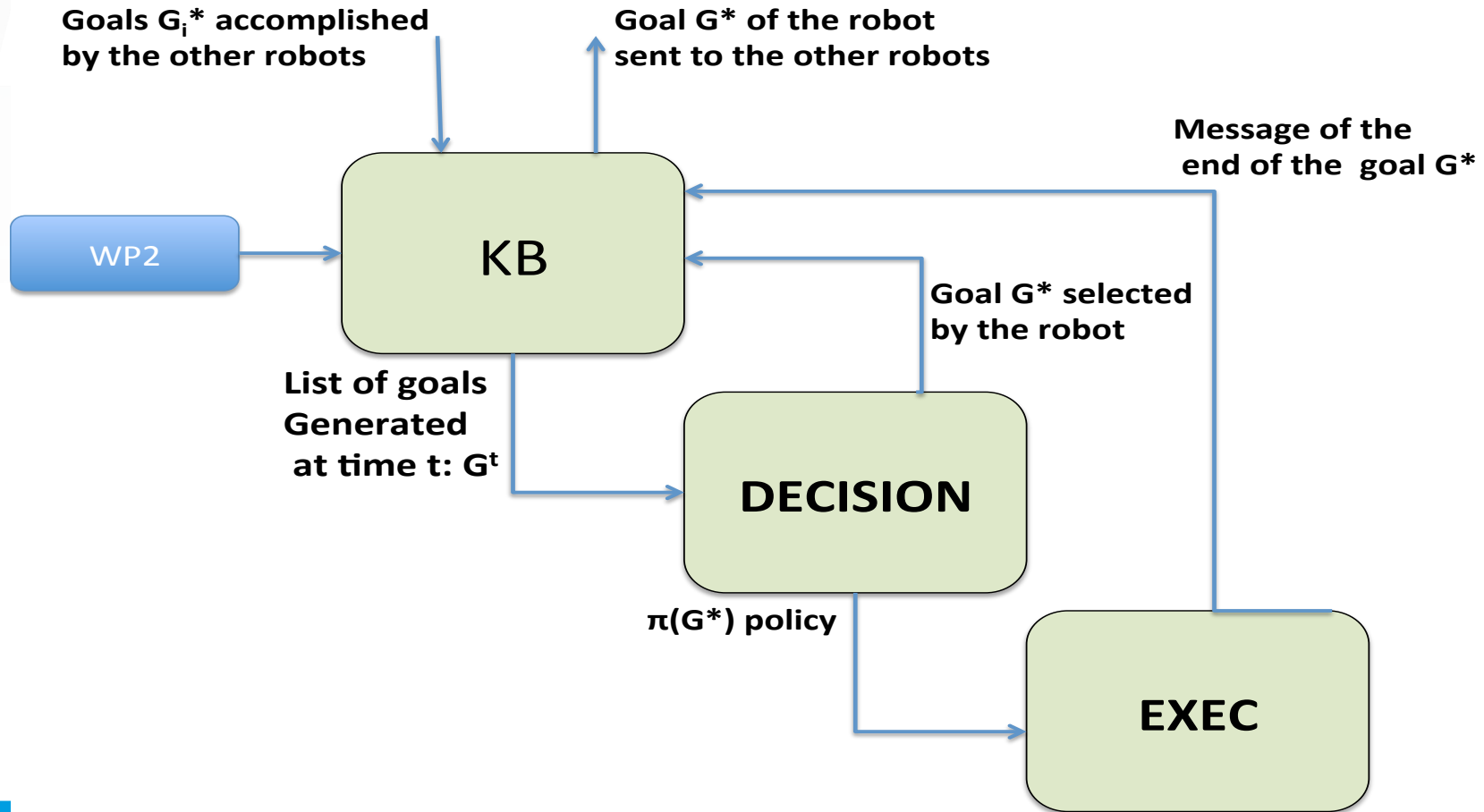
- Each local KB generates next goals
- Goals should be communicated
- All KB should be synchronized
- Arrival of new goals
 - Considered according to the **level of interruptibility** of the robot
 - Robots can be **active** (accomplishing a goal) or **idle** to consider new goals
- **Set of goals should be shared between robots**

Sharing information and goals and planning

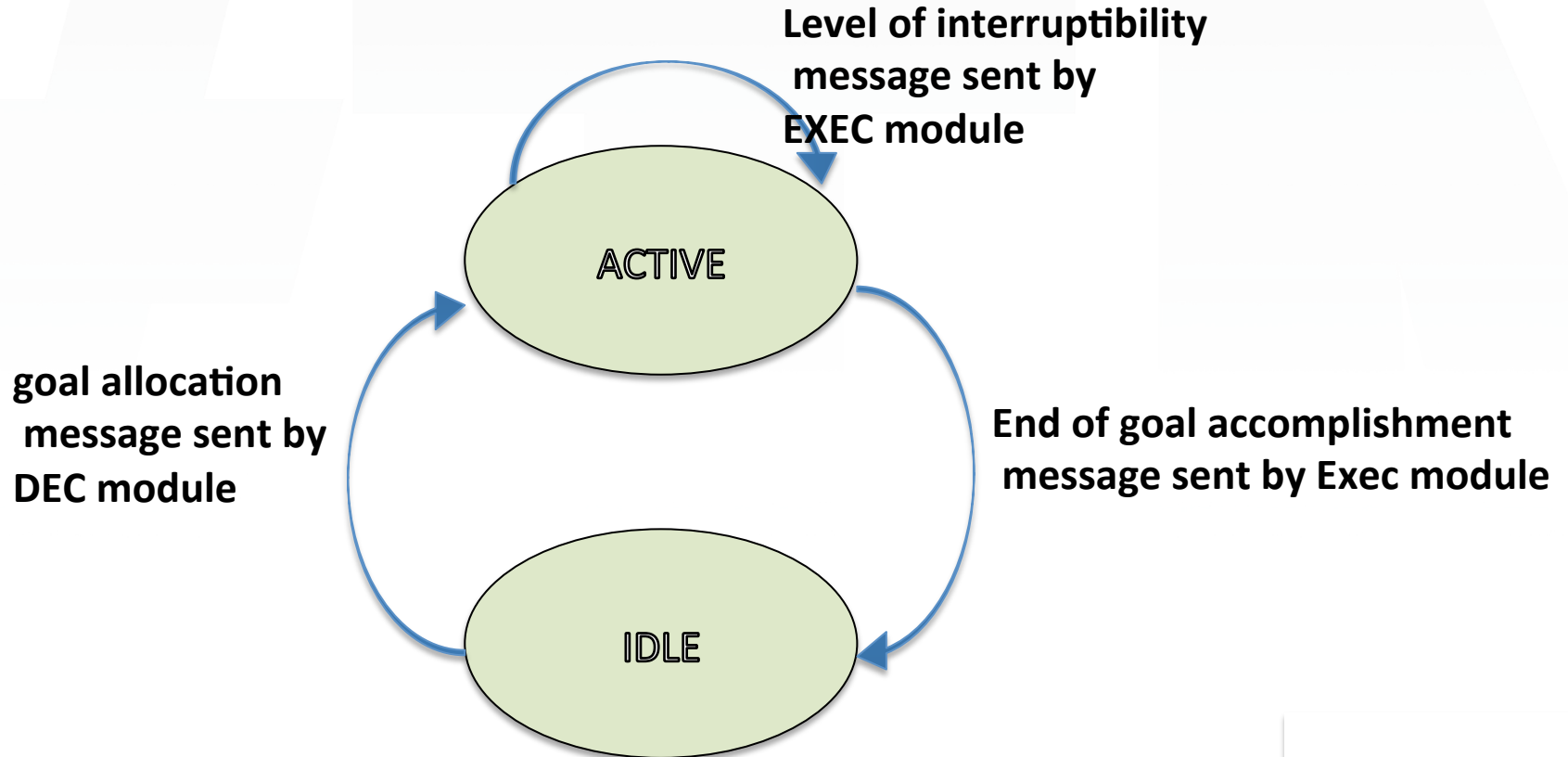
- When KB are synchronized (goals are communicated)
- Each robot computes the value of its optimal policy to accomplish a goal. The vector of values are sent to all robots.
- Each robot has a matrix *[Goals x Robots]* expressing the value of accomplishing a goal by a robot.
- **Augmented MDP** planning technique

Unique Max for Agent A_n , then no conflict, G2 is allocated to and the corresponding line and column are removed

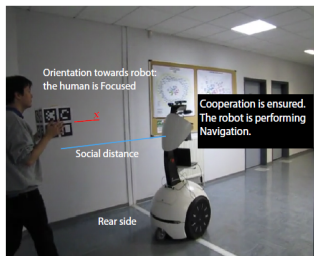
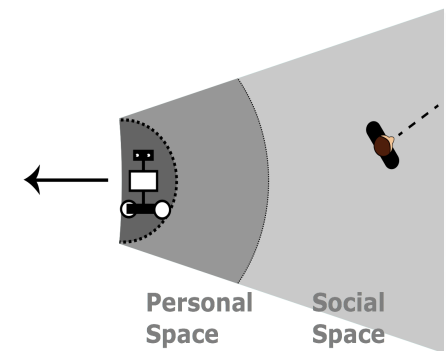
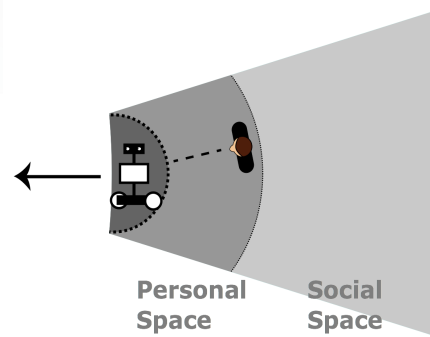
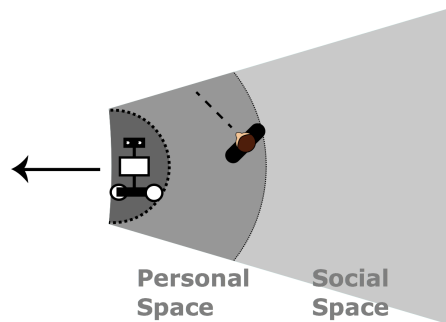




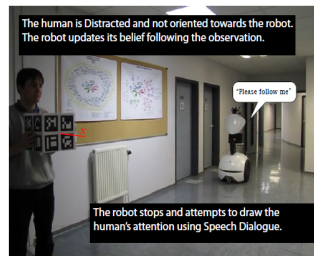
Status of execution



• Hierarchical factored decision model for Escorting



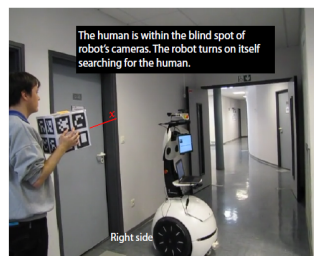
(a) Navigation



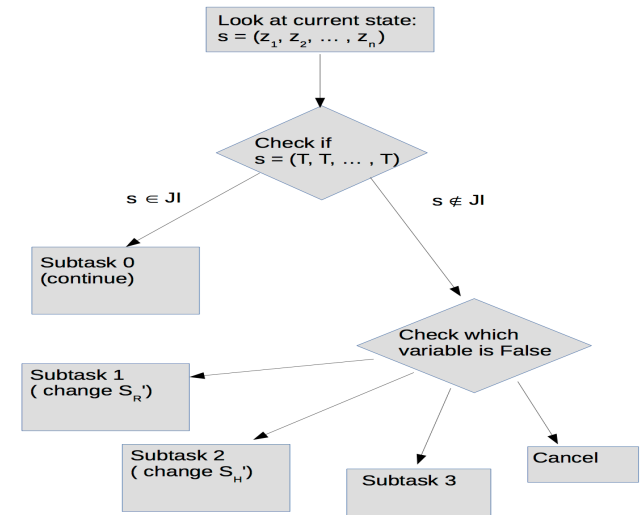
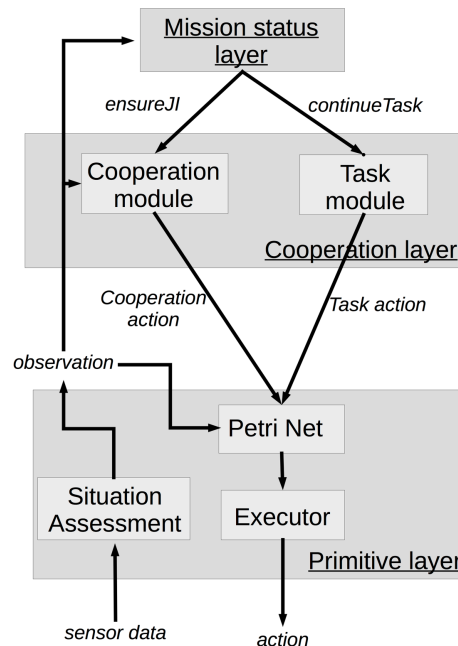
(b) Human distracted



(c) No detection



(d) Searching for human



- **T11: Knowledge-based representation**

- First version with Semantic and static (SEM) and Commonsense (COM Knowledge using prolog-like predicate program (M12, **GREYC-SU**)
- New version with temporary (TEMP) under development by SU (**Due by M18**)

- **T12: Commonsense and spatial reasoning**
 - (due by M24)

- **Static Knowledge on the environment**
is-a(fastFood,restaurant).
instance-of(mango, womenDressShop).
nearby(mango, desigual).

- **Temporary Knowledge on events**
goal('secure', L) :-
unknownObject(X),
at(X, L).
goal('assist', X):-
people(X),
detected(X)

goal('escort', X) :-
people(X),
ask_escort(X).

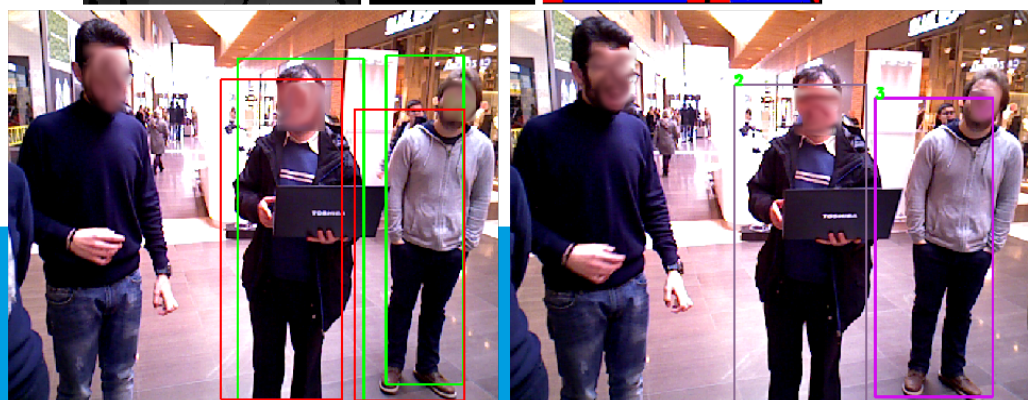
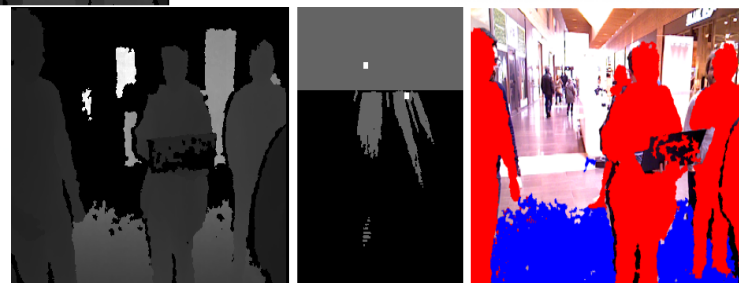
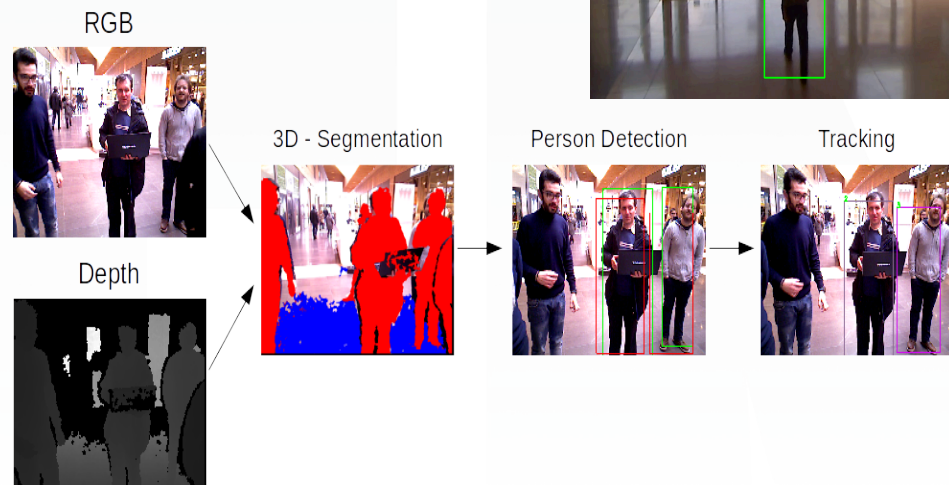
- **Temporary Knowledge on status robots and their goals**
status(idle), status(active)
current_task(goal_id, Interruptibility_level)
Activity(robot_id, goal_id)

- **T21: image/video processing**

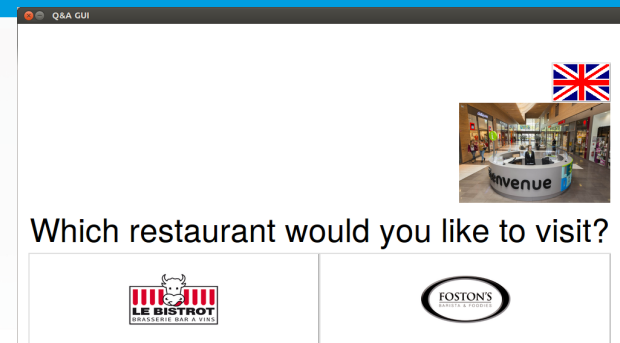
- First result obtained with external cameras
- On-board cameras :
 - Face detection
 - People detection and tracking

- **T22: Event detection**

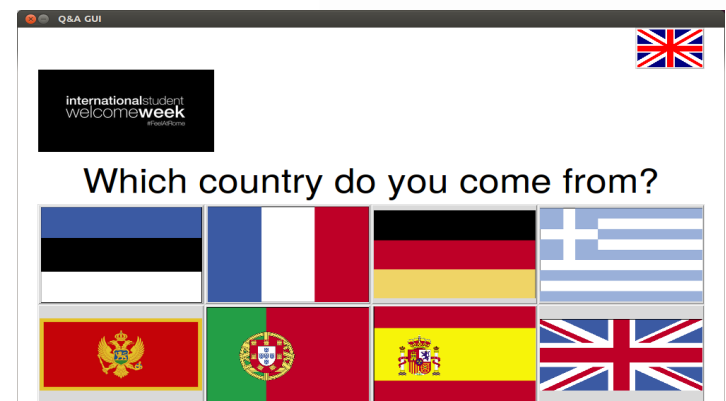
- Detection and tracking for escort
- Behavior people understanding
 - People approaching
 - People surrounding the robot
 - People going away



- **T31: Multi-modal short-term human-robot Interaction**
 - **Developing a simple language for defining interaction template**
- **T32: Human needs estimation**
 - **Estimating the behavior through the moving**
 - **Dialogue**

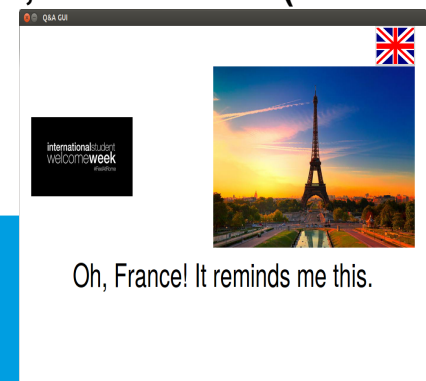


ask<whichActivity, {shop, restuarant}>

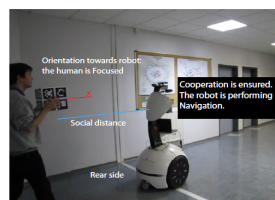


ask<ComeFrom, "country", GetCountries(Continent)>

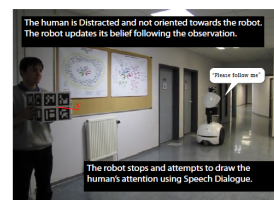
state <ShowInfo, Country>



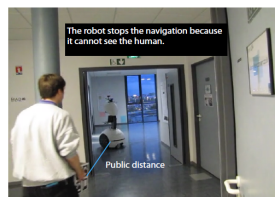
- **T51: ROS Architecture**
M3(Sapienza, GREYC)
- **T52: Definition of use cases** **M12 (GREYC)**
 - 1. Robot advertising and simple interactions, 2. Extending to multiple robots; 3. Complex dialogue and escort, 4. General demo
- **T53: Setup of the robots**
M14 (Sapienza)
- **T54: Multi-robot demo**
on June 2017, M15 (All)
- **T55: under development**



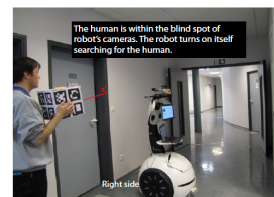
(a) Navigation



(b) Human distracted



(c) No detection



(d) Searching for human



- Behaviour understanding:
 - Moving towards the robot
 - Moving away from the robot
 - Surrounding the robot
- More robust perception
 - 2D detecting and tracking for escort
 - Identification/ Re-identification
- Demonstration in June and September 2017

Deliverables				
Title	Nature	Delivery date (month)		Partner in charge
		Contractual	Actual	
KB environment modelling	R	M18	M18	SU
Software	S	M24	M24	SU
Common sense Reasoning	R	M24	M30	SU+GREYC
Detection from external camera	R	M24	M18	VUB+GREYC
Activities detection (partial)	R	M24	M28	VUB
GUI specification	R	M21	M18	Sapienza
GUI software	S	M21	M18	Sapienza
Human needs	R	M27	M24	GREYC+ Sapienza
Software (partial)	S	M27	M30	GREYC + Sapienza
Navigation	R	M24	M12	Sapienza
Software	S	M24	M24	Sapienza
Multi-robot settings	R	M30	M27	GREYC
Software multirobots	S	M30	M30	GREYC
Architecture definition	R	M9	M9	GREYC
Use case definitions	R	M3	M3	GREYC
Robot setup	R	M9	M9	Sapienza
General demonstration	R+S	M30	M27	GREYC

N°	Date	Location	Attending partners	Purpose
1	April 2016	Bern	Sapienza, GREYC	Multi-robot specification
2	June 2016	London	SU, Sapienza, GREYC	Multi-robot settings
3	September 2016	Phone	Sapienza, GREYC	Extending GUI to speech recognition
4	October 2016	Phone	VUB, GREYC	Perception: image and video analysis
5	October 2016	Roma	GREYC, Sapienza	WP4 and WP3
6	November 2016	Caen	All	Demonstration use case II, CANCELLED
7	April 2017	Brussels	all	WP2 and June meeting

Published : 2 journals and 5 conference papers

1. Valerio Sanelli, Michael Cashmore, Daniele Magazzeni, and Luca Iocchi.
Short-Term Human Robot Interaction through Conditional Planning and Execution.
In *Proc. of International Conference on Automated Planning and Scheduling (ICAPS)* 2017 (to appear).
2. Eugenio Sebastiani, Raphaël Lallement, Rachid Alami, and Luca Iocchi. Dealing with On-line Human-Robot Negotiations in Hierarchical Agent-based Task Planner.
In *Proc. of International Conference on Automated Planning and Scheduling (ICAPS)* 2017 (to appear).
3. Fabio-Valerio Ferrari, Laurent Jeanpierre and Abdel-Ilhah Mouaddib, Flexible POMDP Framework for Human-Robot Cooperation in Escort Tasks, International Joint Conference on Autonomous Agents and MultiAgent Systems (AAMAS), extended abstract, Sao Palo, Brazil, May, 2017
4. Esra Erdem, Michael Gelfond, Nicola Leone:, Applications of Answer Set Programming. *AI Magazine* 37(3): 53-68 (2016)
5. Esra Erdem, Volkan Patoglu, Peter Schüller:, A systematic analysis of levels of integration between high-level task planning and low-level feasibility checks. *AI Commun.* 29(2): 319-349 (2016)
6. Ezgi Demirel, Kamil Doruk Gur, Esra Erdem: Human-Robot Interaction in a Shopping Mall: A CNL Approach. *CNL* 2016: 111-122
7. Esra Erdem, Volkan Patoglu, Zeynep Gozen Saribatur:
Diagnostic Reasoning for Robotics Using Action Languages. *LPNMR* 2015: 317-331

Submitted : 2 conference papers

1. Fabio-Valerio Ferrari, Laurent Jeanpierre and Abdel-Ilhah Mouaddib, Multi-level POMDP Framework for Human-Robot joint activities, (*Under submission*), 2017
2. M. T. Lázaro, F. Montesanti, A. Vanzo, L. Iocchi High-level Formalization and Execution of Human-Robot Multi-Modal Interactions. (*Under submission*), 2017

- **Software developed during the project and released as open-source**
 - **thin_navigation ROS package:** localization and navigation modules for dynamic environments developed within Task 4.1 - https://bitbucket.org/ggrisetti/thin_navigation
 - **PNPgen library:** library for plan generation from PRU domains developed within Task 4.2 - <http://sites.google.com/a/dis.uniroma1.it/petri-net-plans/pnp-generation>
 - **thin_mapper ROS package:** offline 2D mapping for dynamic environments developed within Task 2.1 - https://bitbucket.org/ggrisetti/thin_mapping (upon request)

- **Tourisme numérique at centre international de Deauville (TN4) (March 2016):** a plenary talk has been given at TN4 about COACHES and tourism
- **Les assises du handicap, Caen (Novembre 2016),** organized by the mayor of Caen city: a talk has been given on COACHES and assistance of disable people.
- **Les journées numérique de l'ANR (Novembre 2016), Paris:** Ethics and robotics session where COACHES has been presented and the ethical issues that can be faced by using COACHES robots in public areas.
- **Maker-Faire (Rome, Italy, October 2016):** public demonstration of robot interaction in a very crowded environment.
- **France 3 TV, midi en france show (Cabourg, France, November 2016) :** robot interacted with the invited people to the show.
- **RAI TV show (Rome, Italy, October 2016):** dissemination of the research on social robots in public environments on the national TV.
- **IAB Forum (Milan, Italy, November 2016):** presentation of the robot and of the research on social robotics at IAB forum
- **Coaches.greyc.fr** the web site of the project is maintained and up to date with new results and demonstration (pictures, video, publications, ...).

- A multi-service multi-robot system and programmable services;
- A software for service multi-robot and independent from the physical platforms;
- Possible deployments in different environments;

**LES RIVES
DE L'ORNE**
SHOPPING & LOISIRS



Au revoir et merci pour votre
participation