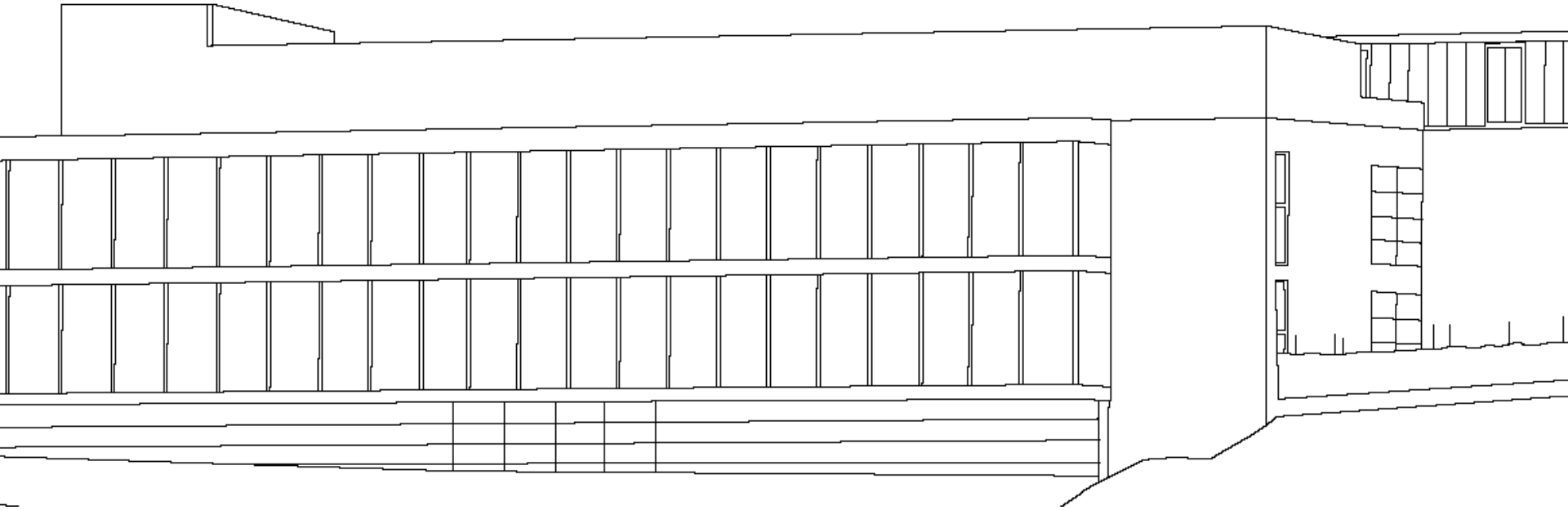
Using multiple robots to develop flexible, cost-effective, dependable, and user-driven applications

IWARD & ROBOSWARM: lessons learned



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Who we are

We are **a private Research Centre**, **market**-oriented and dedicated to get through innovation and technological development the biggest **impact in economic terms.**

We contribute to the business and social development, transferring new technologies to the existing companies, or promoting the creation of new business activities.

FATRONIK-

We are part of TECNALIA,

Private and Independent Technological Corporation composed of 8 Technological Centres:

AZTI, CIDEMCO, ESI, FATRONIK, INASMET, LABEIN, NEIKER y ROBOTIKER

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Figures of TECNALIA in 2007

1st Private technological entitiy in Spain

5th in Europe

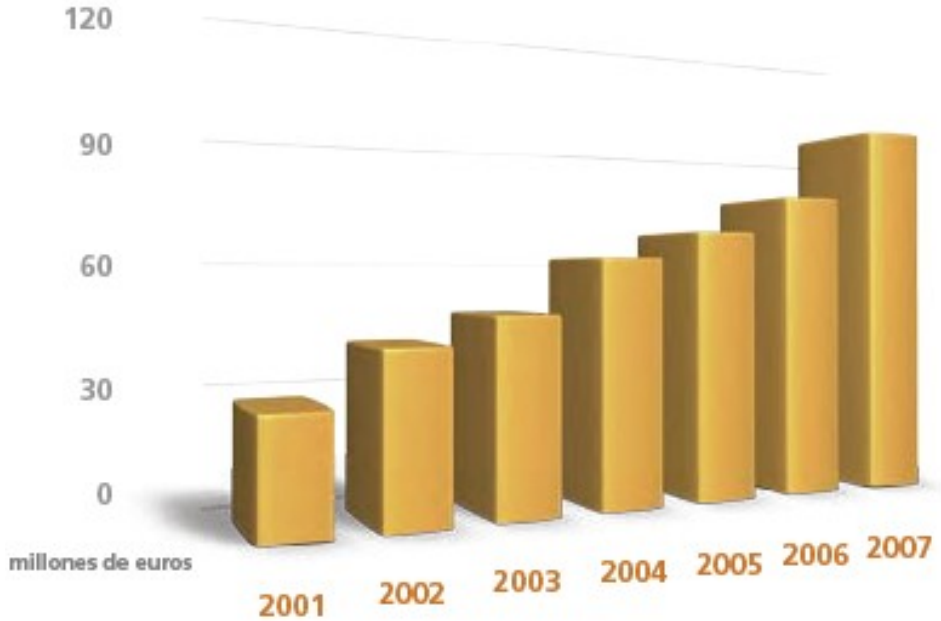
111 Million euros

total income

1.322

PEOPLE

in the workforce



3.235

CLIENTS

19 PATENTS pending

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Introduction

The idea of having self-configurable, low-cost and robust multi-robot systems presents evident advantages for their use in everyday applications, as for example:

- Low cost per robot: as each robot is quite simple
- Adaptability to changes in the environment
- Better area coverage: compared with few robots

...

Fatronik-Tecnalia is member of two FP6-EU projects related to this topic: ROBOSWARM and IWARD.

Despite their similarities and some common roots, each of these projects progressed in different direction:

IWARD: has been oriented into the development of a versatile multi-robot system for hospital environment that unburdens hospital staff from time-consuming routine jobs. In fact, a modular design forms the basis for adding/removing modules with task-related functionality to the robots.

ROBOSWARM: is oriented to the development of an open knowledge environment for self-configurable, low-cost and robust robot swarms. Cleaning in a hospital has been chosen as its main application test-bed.

This has oriented the main goals for each project...

IWARD partners

FRAUNHOFER -IAO (GERMANY)

ECOLE NATIONALE SUPERIEURE DES MINES DE SAINT-ETIENNE (FRANCE)

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ROBOSWARM partners

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IWARD

IWARD:

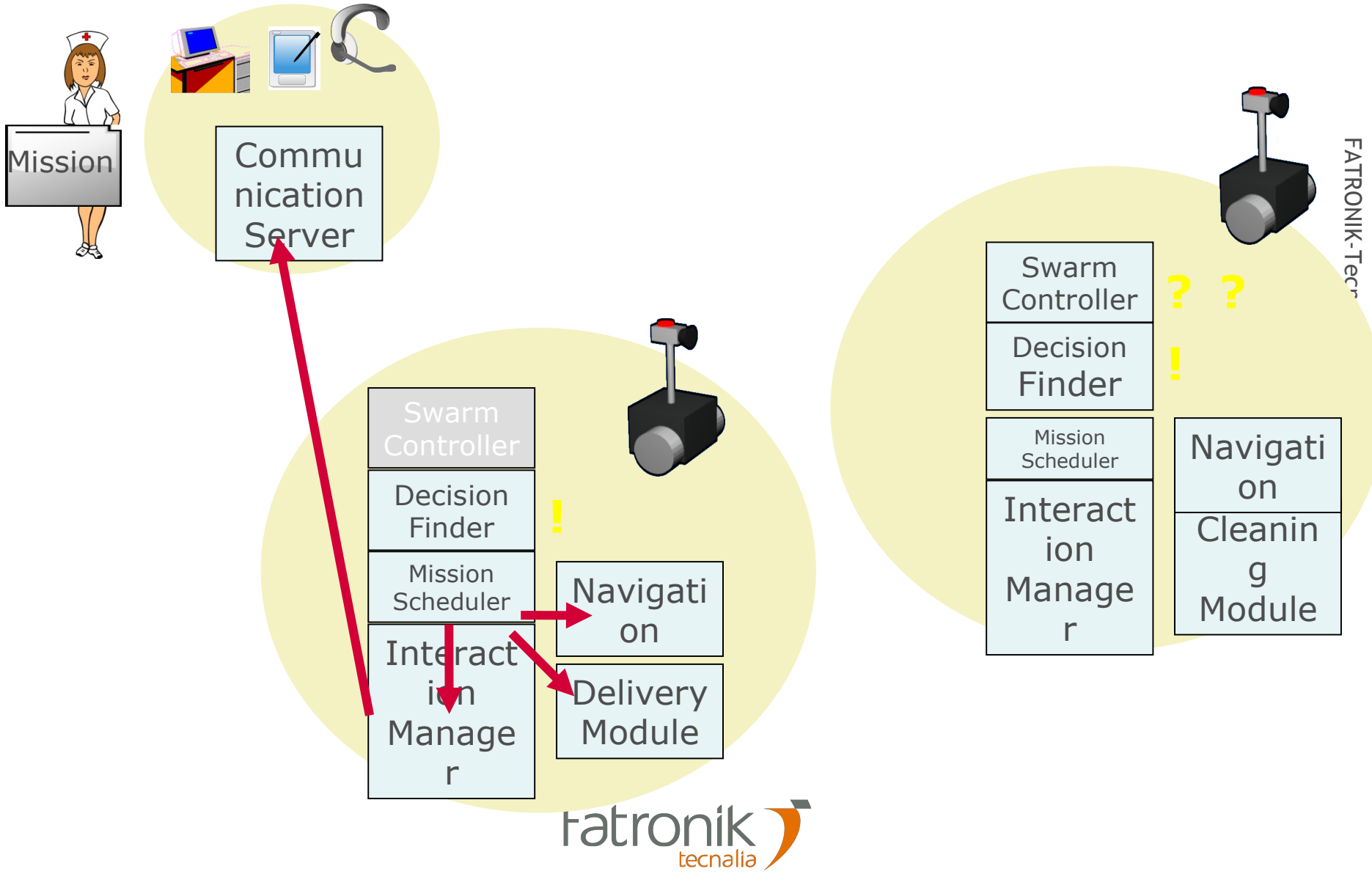
Versatility and “plug&play” modules require more complex robots, which means higher cost, and so (due to our limited budget): less robots in the project.

But there is another key requirement that also marks the direction of the project:

the system is being designed to be used in real environments.

Through different contacts with health-care professionals, project members identified some reticence to deal with robots in their working environment.

General view



IWARD – Lessons learned:

1) Never mention the word “RoboNurse”, or suggest that robots will do the job of nurses.

2) Focusing in real applications has big implications:

2.1) Institutions will want to validate if robots are performing well.

2.2) The worker must “understand” what the robots are doing (is it working well? Why is it doing that?)

And these two points are very tricky if we follow a strict “swarm” approach (How can we validate “emergent behaviour”?).

That's why in IWARD we follow more a “self-organized team of robots” idea.

ROBOSWARM

ROBOSWARM:

In ROBOSWARM, the main focus is on the interaction between the robots and the knowledge infrastructure. This makes the robots themselves not so central to the project.

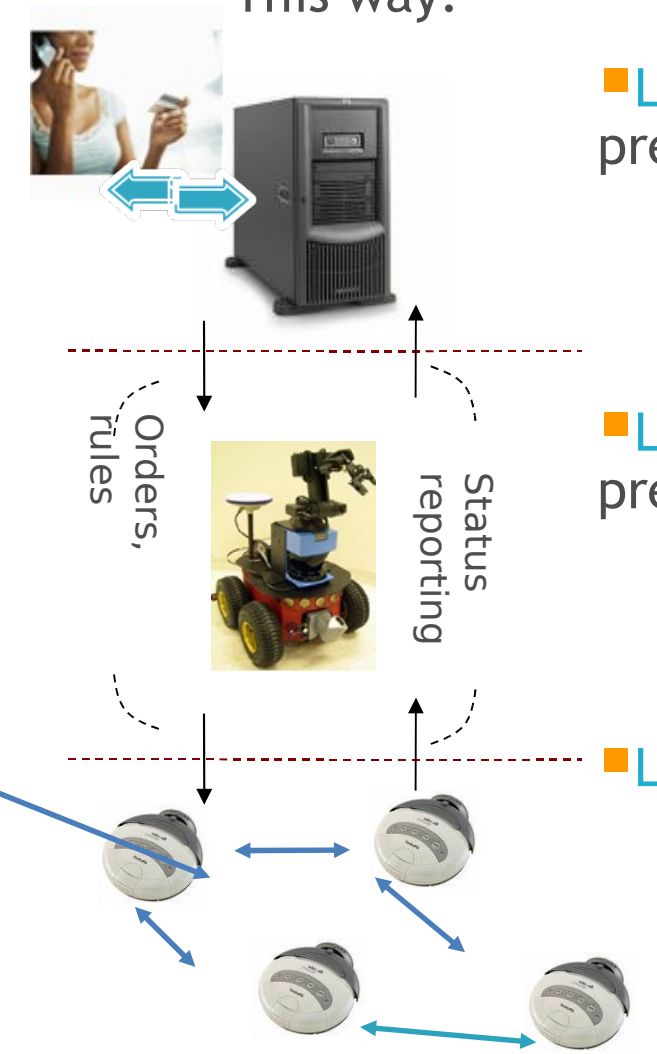
ROBOSWARM system= Robots + knowledge infrastructure

This way, ROBOSWARM considers that:

- The ROBOSWARM system is a ***distributed agent system***
- Each agent has a set of roles & capabilities
- Roles and capabilities are defined in terms of the *services* an agent exposes/invokes
- Agents live in an ambient computing environment (memory everywhere using RFID tags, memory and computation units may be mobile and temporarily not co-located...)
- The ROBOSWARM system execution platform is a service orchestration engine

ROBOSWARM:

This way:



- L1: "Big Brother" – swarm mission and its preparation (strategic) planning:
  - analyzes the generic goals given by human(s)
  - generates ext./int. service requests
  - synthesizes behavioural constraints and rules
  - communicates the rules to L2 and L3 robots
- L2: "Scouts/messanger robots" – mission preparation and maintanance on the spot
  - area exploration, semantic mapping
  - deploying RFID tags (create mission infrastructure)
  - write the mission context on tags (create *context awareness*)
- L3: "Swarm of Workers" - mission performers
  - accomplish main workoperations
  - coordinate tasks locally (e.g., using auction nodes)
  - propagate mission relevant knowledge

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ROBOSWARM – Lessons learned:

1) If robotics is the science of embodied cognition, we have to understand very well the limits that having “low cost” impose in our system. In ROBOSWARM, low cost robots have low quality sensors & actuators & computation, which greatly limits what the robot can do...

2) Another aspect of having “low cost” bodies, is that when they operate in a real environment with people, they're perceived as toys, not useful stuff

3) Once again, if we want to validate if robots are performing well... How can we validate “emergent behaviour”?

4) If the system has to react to human instructions... how can we make it react in a way that humans perceive is “correct”? (hence the need of the “big brother” approach that organizes this part).

General Lessons Learned

General Lessons learned:

1) It's difficult to get rid of some place where tasks are received, analyzed and dispatched. In other words, it's difficult to program an “emergent behaviour” for robots that is effective, works reliably, and is accepted by the people around...

In other words, people want to push a button, and see that the required action is happening inmediately...

Both ROBOSWARM and IWARD share a similar concept of explicit task planning and allocation for general tasks

2) The concept of “emergent behaviour” is quite against traditional “resource planning” of the people

3) The “swarm approach” orients the robot's design to be low cost... and this limits what the robots can do. In this sense, is not “swarm“ against “versatile”?

4) The “swarm approach” makes it hard to know what the robots are doing... How can a robot tell you what it's doing, when it doesn't know itself? Can you trust a robot that doesn't know what it's doing if you see it in a corridor?

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Why I changed the title of this session

Three main reasons:

1) We have not followed strictly the „swarm approach“ in these projects

2) Checking and measuring the emergent behaviour of a swarm is not a trivial task

3) Both projects are focused towards use in real applications. Are real end-users prepared to swarm-robots moving around?

Conclusions

Conclusions

Open knowledge environment for self-configurable, self-learning and robust robot swarms

Low cost, simple robots

Single task (cleaning)

Data is everywhere: RFID tags and communication with a central server

Low cost makes difficult to have good quality data, enough computation, ...

iWARD

Development of a versatile multi-robot system for hospital environment

Complex, modular & scalable robots

Multitask (surveillance, delivery, cleaning, ...)

P2P network is used to communicate each member of the system

IWARD is looking for versatile and multipurpose robots

In both projects we have to prove and validate the results.

In both projects we decided to move from a "swarm approach" to a more classical "multi robot approach", because:

* How can we program (not explicitely) a behaviour? (have an emergent behaviour)... Maybe training? How do you prove that it was well trained?
* How can swarms be programmed, tested & validated?
* How can its users perceive that is working properly?

Final questions:

If new AI systems are complex, adaptative, and self-organizing...

- How can we “certificate” that they will always perform properly in real world conditions?
- How can the end-user perceive that they are doing what they should?

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