A Hierarchical Control Architecture Applied to Real Mobile Robot

Paulo Alvito

pja@isr.ist.utl.pt

2nd ISLab Workshop

Introduction

- What is an autonomous mobile robot?....
- What should be its main features in terms of decision-making capabilities?.......
- How should its sensory and actuator systems be organised?...

... These are just some of the questions to pose as a departing point to the implementation of a control architecture.

Control Architectures

- Motivation
  - The robot needs to plan
  - The robot needs to be controlled
  - The robot should react to events
  - The implemented architecture should be robust to unexpected events
- Background

What is a robotic architecture?

"An architecture describes a set of architectural components and how they interact" (Dean and Wellman, 1991)

Control Architectures

- Deliberative Architectures
  - Moravec (1983), Nilsson (1984), Hayes-Roth (1985), Georgeff and Lansky (1986), Laird and Newell (1987), Carbonell and Veloso (1988).
- Behaviour Based Architectures
  - Brooks (1986), Rosenschein and Kaelbling (1986).
- Hybrid Architectures
  - Payton (1986), Georgeff and Lansky (1987), Firby (1989), Arkin (1990), Ferguson (1992), Gat (1992), Simmons (1994).
- Hierarchical Architectures
  - Saridis (1989), Meystel (1993), Albus (1994).

Control Architectures

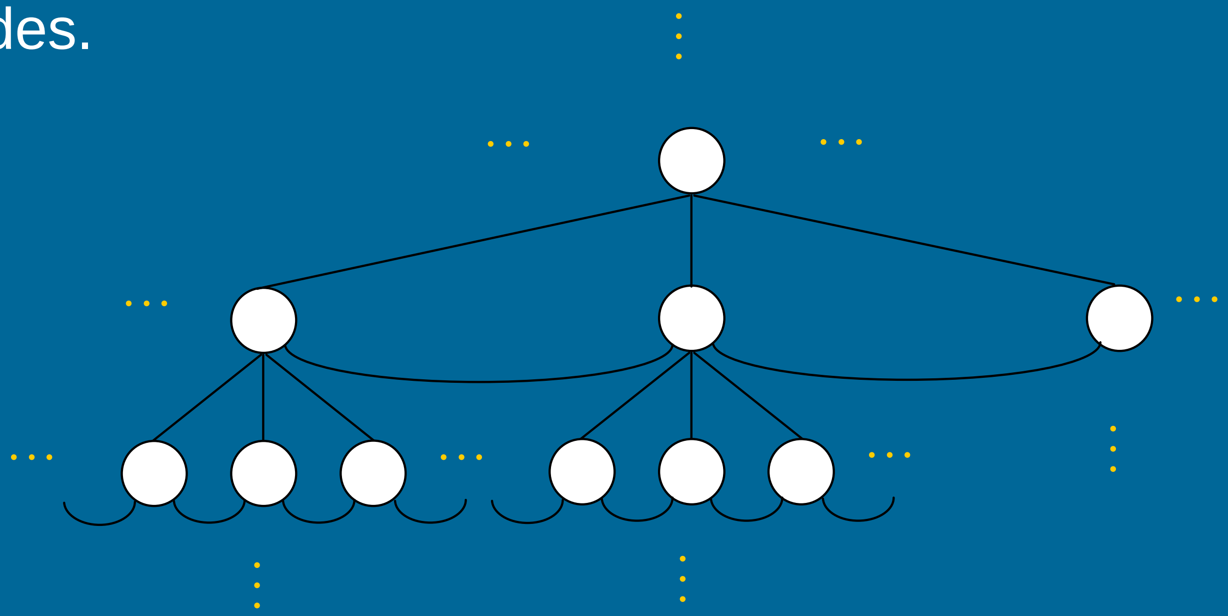
- Whish one is the best???
  - ...... Not to be discussed in this workshop... ;-)
  - There's no perfect architecture that can be applied to every job.
  - Maybe a specific architecture adapts itself better to a specific job.

Current Work

- Goal
  - Apply a control architecture to real mobile robot so that it can perform a find-and-deliver task in an office-building-like environment.
- Critical Issues
  - Different subsystems will have to be combined: navigation, obstacle avoidance and object recognition.
  - Each of these subsystems can be composed of different sensors and actuators.
  - Converging all the information to a decision point can be a bottleneck concerning fast reaction to events...
  - ... but it can be positive concerning the combination of different sources of knowledge and to provide a common actuation.

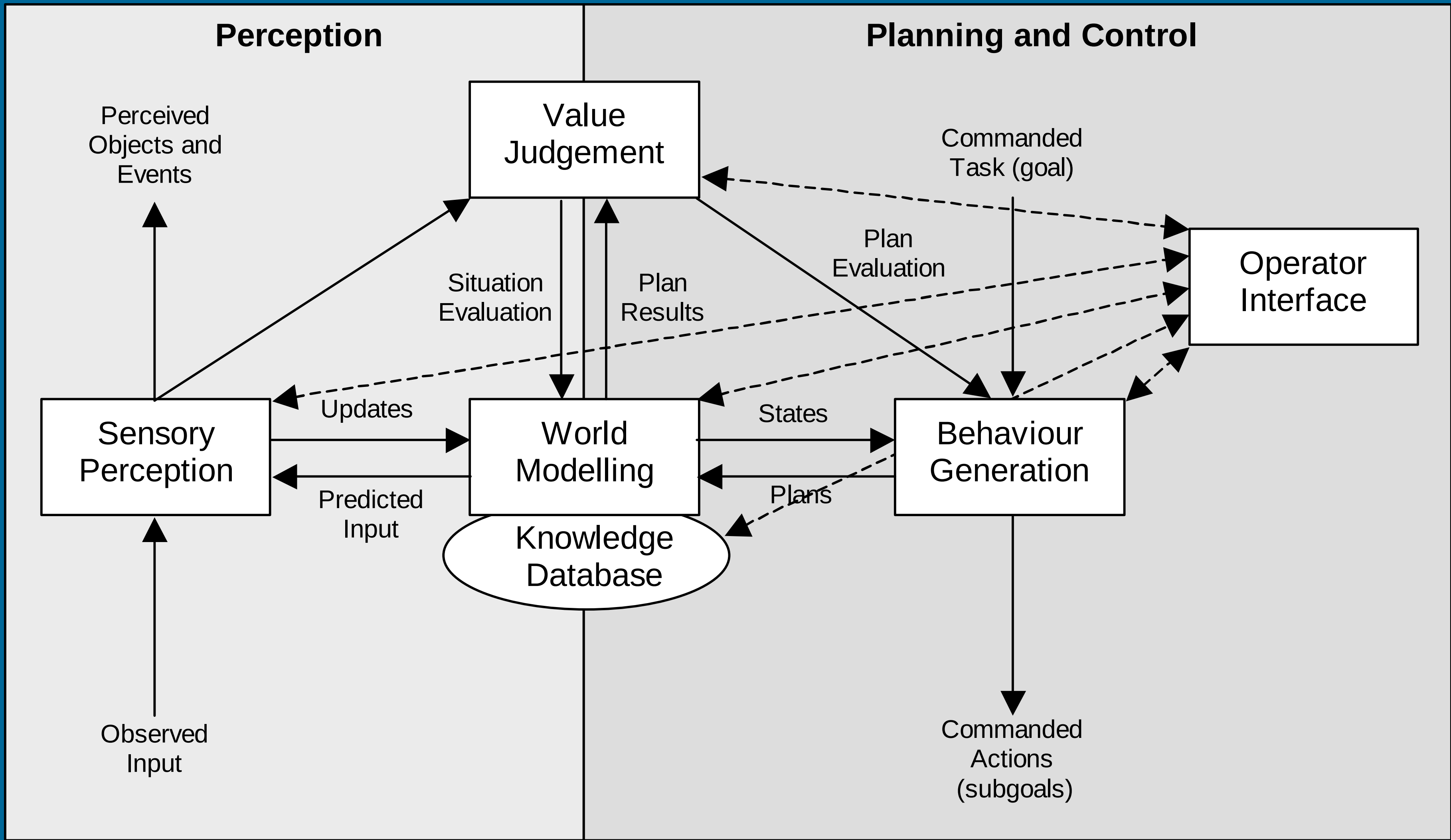
The RCS Architecture

- RCS – Real-time Control Systems
  - Huang, Quintero, and Albus (1991). Albus (1994, 1996, 1997).
- The Node: The Fundamental Unit in the RCS Architecture
  - The RCS architecture is organized as a tree of computational nodes.



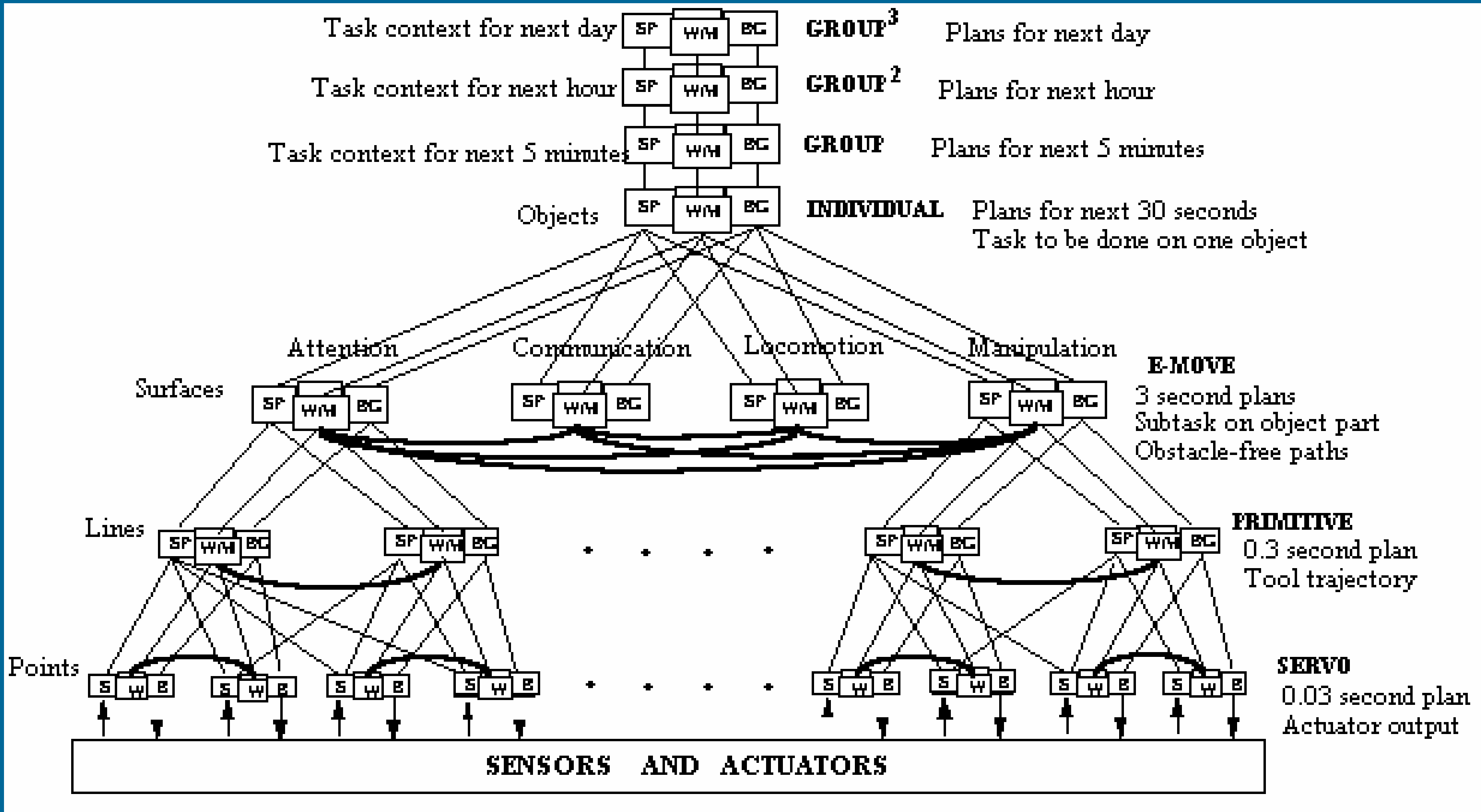
The RCS Architecture

- Fundamental Elements Inside a Single Node



The RCS Architecture

- The RCS Hierarchy



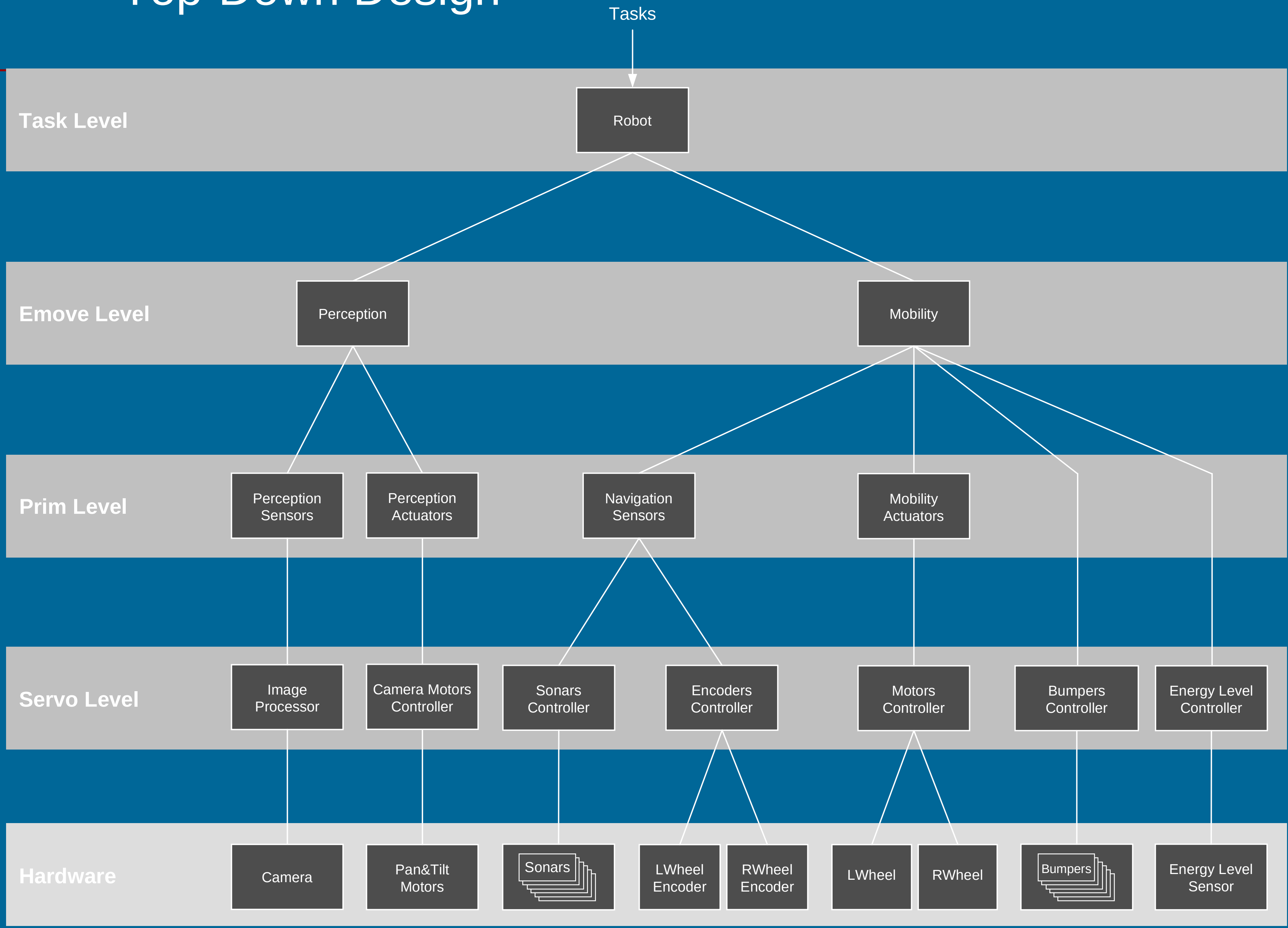
The RCS Architecture

- Advantages
  - Easy to divide the system into modules and to establish relations between them.
  - The architecture is organized into different levels of abstraction.
  - When we are going up in the hierarchy we are following the IPDI principle – Saridis (1983), we are *increasing intelligence while decreasing precision*.
  - Higher levels plan based on simbolic descriptions and lower levels deal with signals.
  - The hierarchy “drives” the system for the goal but, but at the same time it leaves some compliance so that modules can react to unspected events.

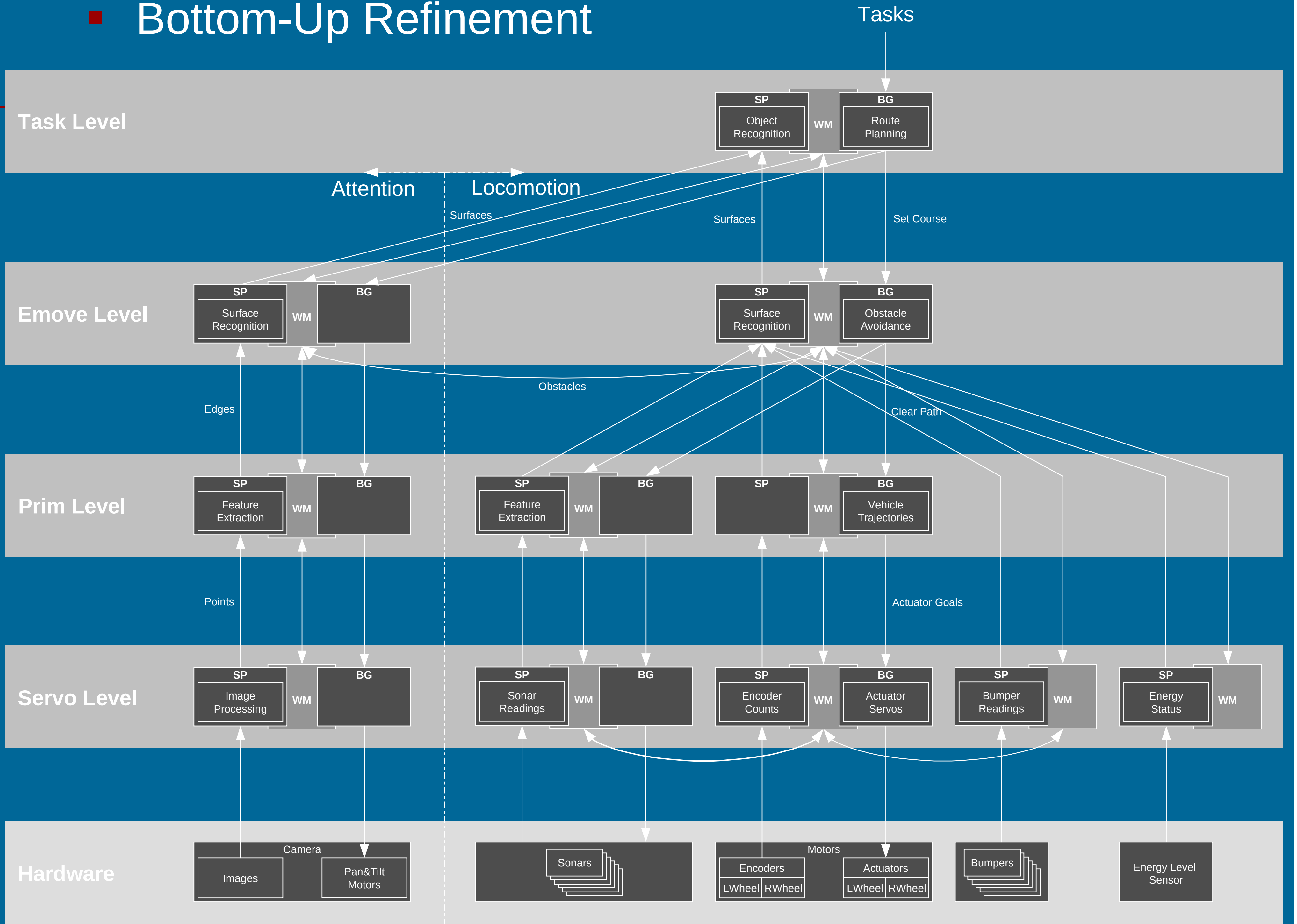
RCS Architecture Applied to a Real Mobile Robot

- Top-Down Design
  - Main goal: “the robot should be able to move to different locations specified by users”
  - Sub-goals:
    - Determine the order in which to visit offices
    - Plan paths to those offices
    - Follow paths reliably
    - Avoid static and dynamic obstacles
    - Identify offices

Top-Down Design

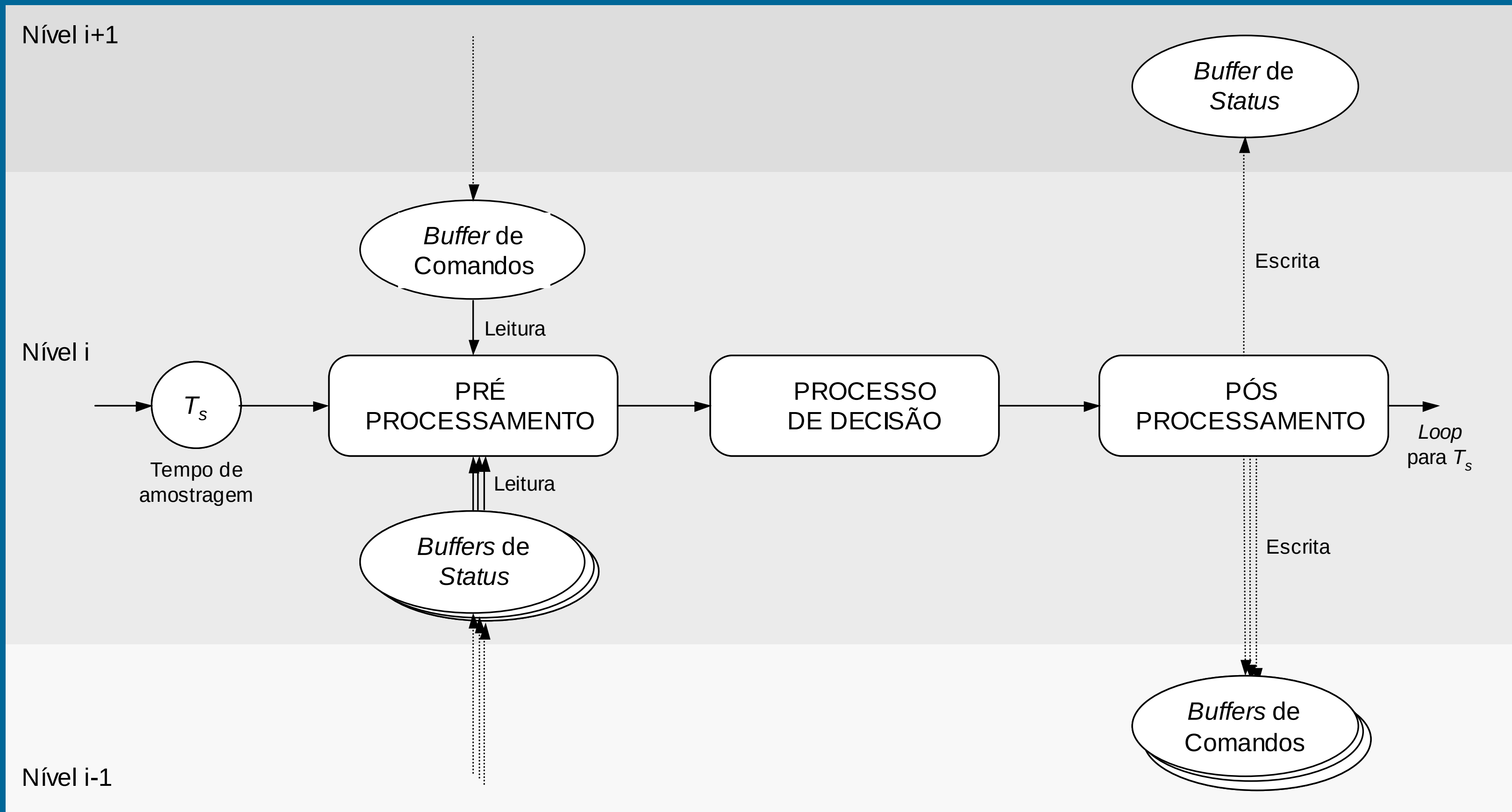


Bottom-Up Refinement



Methodology Application

- Each node is a *thread* and is working assyncronously
- Cyclic looping structure



Future Work

- Carry on with the software implementation. One thread for each module...
- ... Test the interfaces between them (**!**)
- Put more emphasis in the Value Judgment (VJ) module.

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