Agent Architectures

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Original Paper:
"Intelligent Agents: Theory and Practice"
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Introduction

- Earlier, we discussed Agent Theory -how we reason about agents and their properties.
- Shift from theory to implementation.
- How do we actually construct working agents? This is is the area of Agent Architectures.

Formal Definition

- Kaelbling:

"[A] specific collection of software (or hardware) modules, typically designated by boxes with arrows indicating the data and control flow among the modules. A more abstract view of an architecture is as a general methodology for designing particular modular decompositions for particular tasks."

Paradigm A: Symbolic AI

- The classical approach to building agents is to view them as a certain type of knowledge-based system.
- Basis is the "physical-symbol system hypothesis"
- Deliberative agent architecture - contains an explicitly represented symbolic model of the world, in which decisions are made through logical reasoning, based on pattern matching and symbolic manipulation.

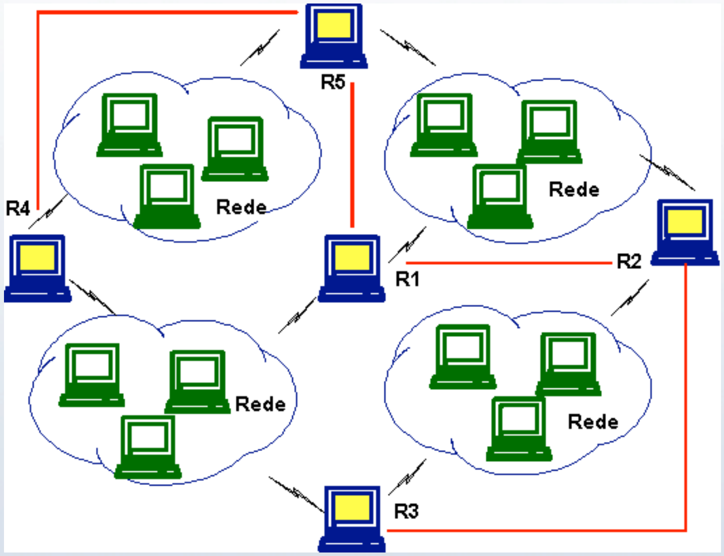
Two Problems:

- Transduction problem: How to translate the real world into a symbolic description
- Representation and reasoning problem: How to symbolically represent information about complex real-world entities and how to get agents to reason with this information fast.

Planning Agents

- The design of a course of action that will, when executed, result in the achievement of a goal.
- It has long been assumed that an AI planning system would be a central component of an artificial agent.
- STRIPS: Takes a symbolic representation of the world, a desired goal state and a set of action descriptors. It attempts to find a sequence of actions that will achieve the goal by using a simple means-ends analysis. Completely ineffective on problems that were even moderately complex.
- Despite advances, this is pretty much a dead end.

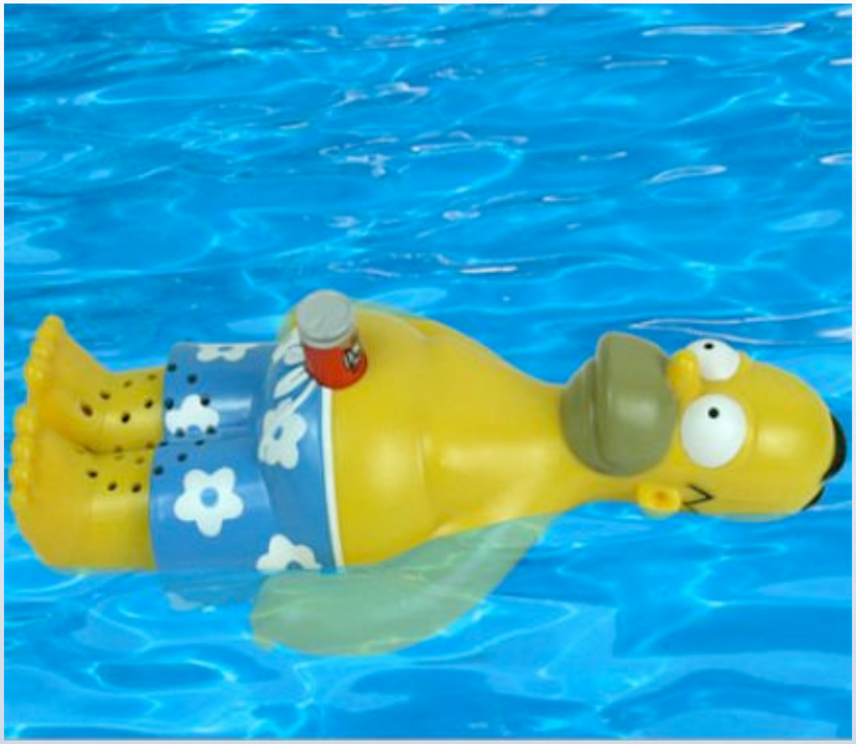
IRMA



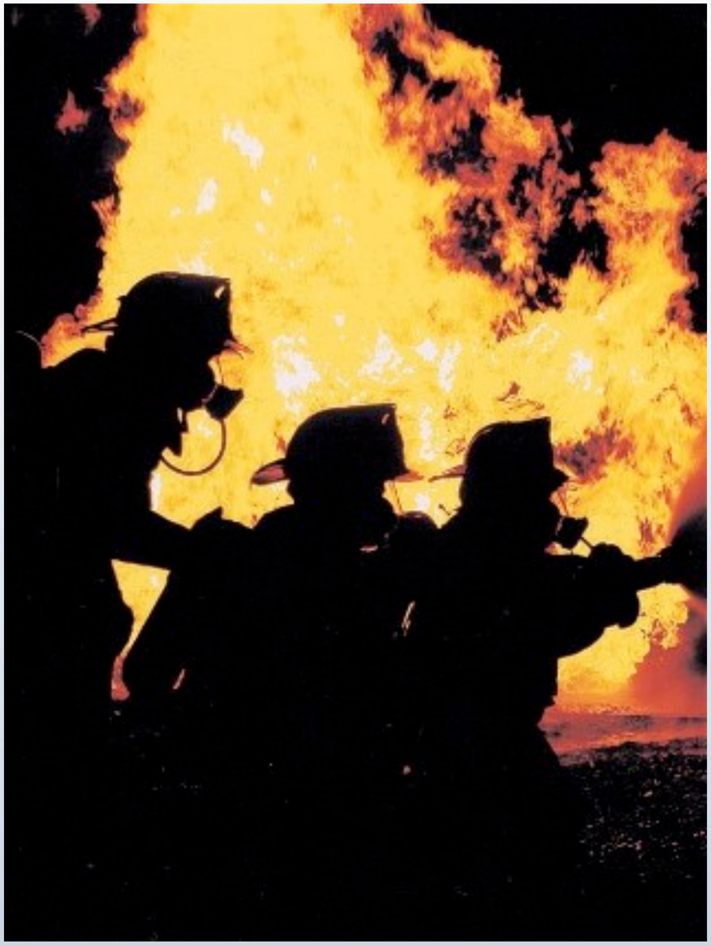
- The Intelligent Resource-bounded Machine Architecture
- Four key symbolic data structures – a plan library, beliefs, desires, intentions.
- Also
  - Reasoner
  - Means-ends analyzer
  - Opportunity analyzer
  - Filtering process
  - Deliberation process

HOMER

- Autonomous agent with linguistic ability, planning, and acting capabilities.
- HOMER – a simulated robot submarine in a 2D "seaworld"
- Takes instructions in English.
- It can plan how to achieve its instructions and can then execute its plans, modifying them as required during execution.
- Homer can answer questions about its past experiences.



GRATE*



- Layered architecture guided by beliefs, desires, intentions, and joint intentions.
- Creates a community of agents that work together.
- The domain-level layer solves problems.
- Cooperation and control layer coordinates agent's activities with the community.

Paradigm B: Reactive Architectures

- Reactive Architectures do not include any kind of central symbolic world model or any complex symbolic reasoning.
- Behavior Languages
  - Three key theses:
    - Intelligent behavior can be generated without explicit representations of the kind that symbolic AI proposes.
    - Intelligent behavior can be generated without explicit reasoning of the kind that symbolic AI proposed.
    - Intelligence is an emergent property of certain complex systems.
  - Backed up by two ideas:
    - Situatedness and embodiment
    - Intelligence and emergence

Subsumption Architecture

- A subsumption architecture is a hierarchy of task-accomplishing behaviors.
- Each behavior competes with others to exercise control over a robot.
- Lower layers represent more primitive behaviors and have precedence over more complex behaviors.

PENGI

- Most everyday activity is "routine" – it requires little abstract reasoning.
- Most tasks, once learned, can be accomplished in a routine way with little variation.
- Architecture based on the idea of "running arguments" – decisions can be encoded into low-level structures.
- This was illustrated in PENGI, a simulated computer game with the central character controlled using this kind of scheme

Situated Automata

Perception

- RULER:
    - Three inputs: the semantics of the input, a set of static facts , and a specification of the state transitions of the world
    - The compiler synthesizes a circuit whose output will have the correct semantics.

Action

- GAPPS:
- It takes as its input a set of goal reduction rules and a top-level goal.
- It then generates a program that can be translated to a digital circuit in order to realize that goal.

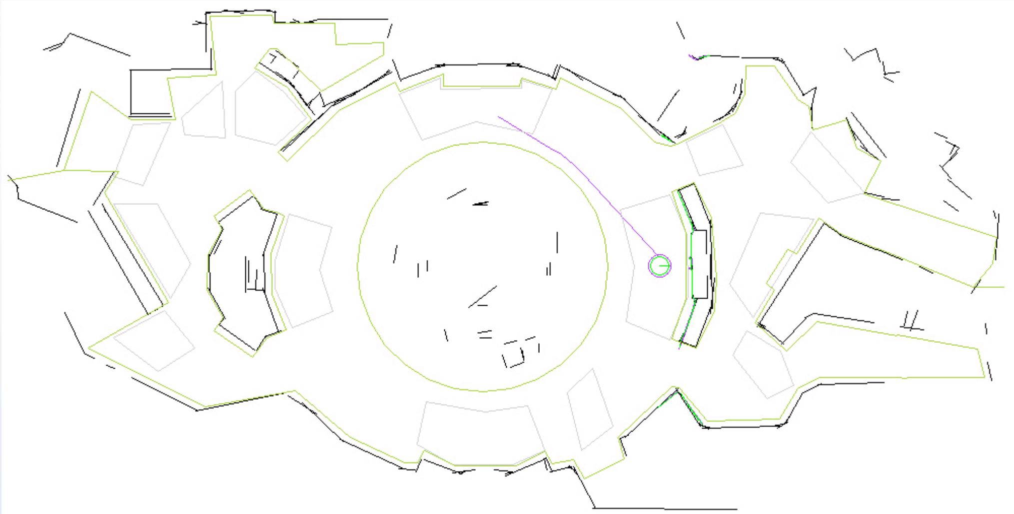
Agent Network Architecture

- An agent is a set of competence modules.
- Individual modules: pre and post-conditions and an importance level.
- A set of competence modules is compiled into a spreading activation network.
- When an agent is executing, various modules may become more active in given situations.
- Similarities between this architecture and neural networks.

Paradigm C: Hybrid Architectures

- Potentially, neither of the first two paradigms can provide a suitable solution.
- Hybrid systems are both deliberative and reactive.
- Layered architecture where an agent's control subsystems are arranged into a hierarchy, with higher levels dealing with more abstract concepts.
- Issue – How to control the interaction between layers?

PRS



- Procedural Reasoning System
- BDI architecture
- Beliefs are known facts.
- Desires are system behaviors
- Intentions are the set of currently activated knowledge areas (partially elaborated reactive plans with set trigger conditions)
- A system interpreter updates the beliefs, invokes knowledge areas and executes actions.

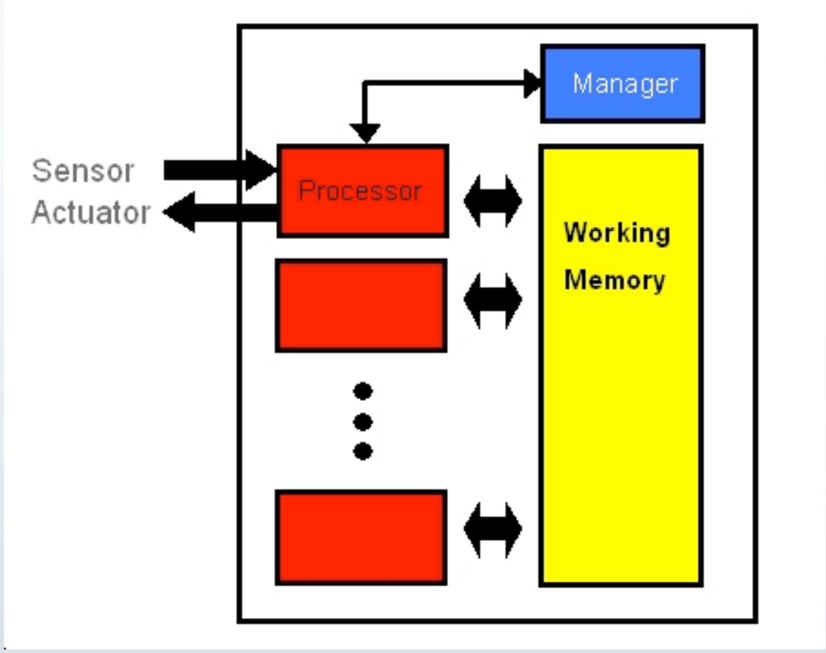
TouringMachines

Note: Wrong kind of “touring machine”

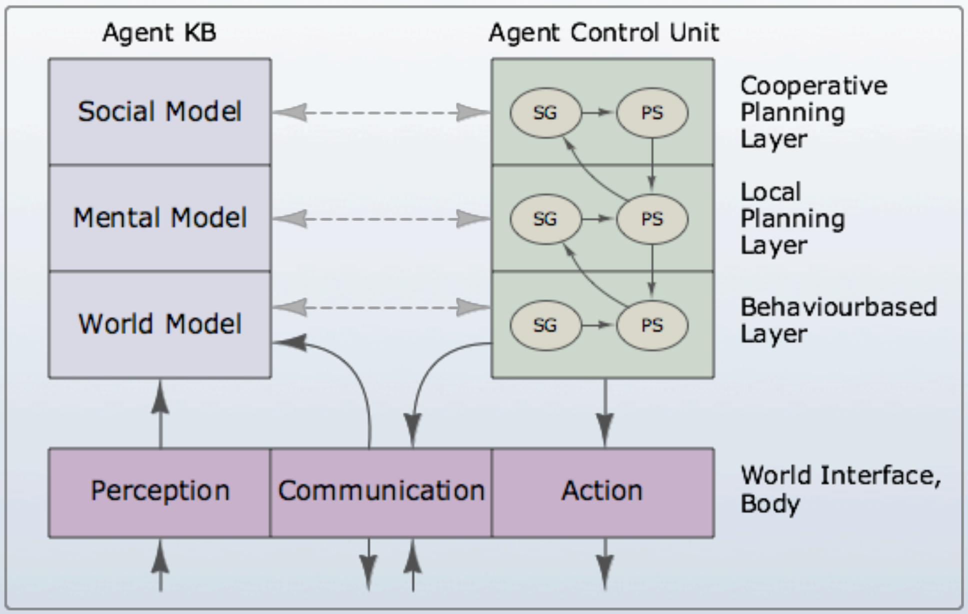
- Perception and action subsystems
- Three control layers. Each layer is an independent concurrent process.
  - The reactive layer generates potential courses of action.
  - The planning layer constructs plans and selects actions.
    - This layer is made of two subsystems: a planner, and a focus of attention mechanism.
- The modeling layer contains symbolic representations of the other entities in the agent’s environment.
- Managed by a control framework.

COSY

- Hybrid BDI-architecture.
- It has five main components: sensors, actuators, communications, cognition, and intention.
- Sensors receive perceptual input.
- Actuators allow the agent to perform actions
- Communications component allows the agent to send messages.
- The intention component contains the control elements that take part in the decision-making and reasoning processes.
- The cognition component is responsible for choosing an appropriate action to perform.



InteRRaP



- Layered architecture, with each successive layer representing a higher level of abstraction than the one below it.
- Also two vertical layers: one containing layers of knowledge bases, the other containing various control components.
- World interface controller and the corresponding world model knowledge base deal with acting, communication, and perception.
- Behavior-based component controls the basic reactive capability of the agent.
- Plan-based component generates single-agent plans in response to requests from the behavior component.
- Cooperation component generates join plans that satisfy the goals of a number of agents.
- Control is both data- and goal-driven. Both primitive actions and messages are generated by the world interface.

Questions?

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