Abstract agent architectures : 'standard agent'

- S = {s_1, s_2 , …} environment states
- A = {a_1, a_2, …} actions
- Abstractly, an agent can be viewed as a function:

action: S* → A

mapping sequences of environments to actions

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Abstract agent architectures

- Nondeterministic behavior environment:

env: S × A → P(S)

- History: interaction agent and environment:

h: s_0 → s_1 → s_2 → …

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Several types of agents

- Behavior of a *purely reactive agent*:

action: S → A

- Agent with *perception*:

see: S → P

action: P* → A

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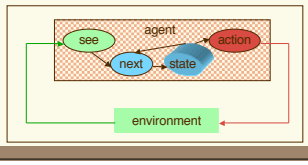
Several types of agents (2)

- Agents with *a(n internal) state*:

see: S → P

action: I → A

next: I × P → I



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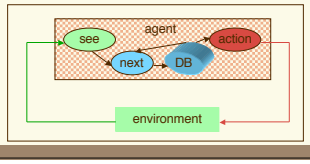
Several types of agents (3)

- Deliberative agent

see: S → P

action: DB → A

next: DB × P → DB



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Agent architectures

- Deliberative systems
  - Based on *physical symbol system hypoth.:*
  - *'GOFAI approach'*
- Reactive systems
  - Based on *physical grounding hypothesis*
- Hybrid systems
  - *Synthesis* of deliberative and reactive systems

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Deliberative systems

- Uses *symbolic* representations, e.g.:
  - Maintains models, e.g. world model
  - Planning (e.g. STRIPS)
  - (Logical) Reasoning
  - Sense-*plan/reason*-act cycle
  - Belief, desires, intentions (BDI)
  - Internal ('mental') state (belief base, …)

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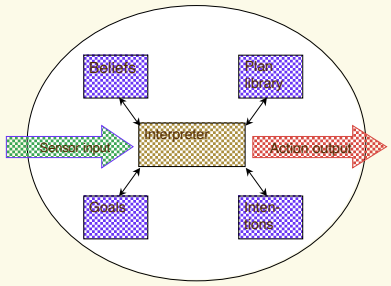
BDI Architecture / PRS



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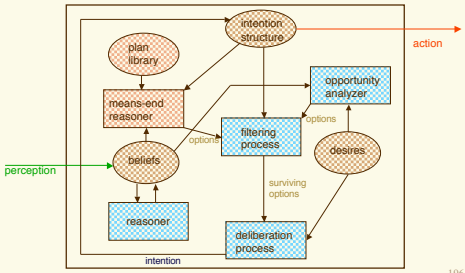
IRMA (Bratman et al. 1987)



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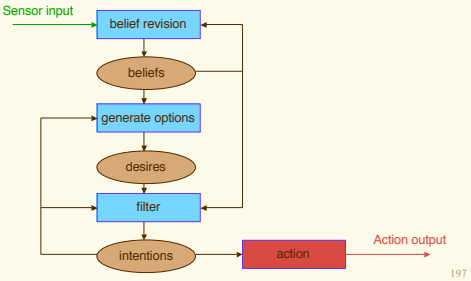
BDI architecture



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Abstract BDI Interpreter (Rao & Georgeff 1991)

- initialize-state();
- **do**
  options := option-generator(event-queue,B,G,I);
  selected-options := deliberate(options,B,G,I);
  update-intentions(selected-options,I);
  execute(I);
  get-new-external-events();
  drop-successful-attitudes(B,G,I);
  drop-impossible-attitudes(B,G,I);
- **until** quit.

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Problems with deliberative systems

- Representation & symbol grounding problem
  - How to *translate* the real world into an accurate & adequate symbolic description
  - How do symbols *relate* to real-world entities and processes?
- Reasoning is *computation-intensive*
  - How to get agents to reason with real world information *in time* for the results to be useful

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Reactive systems

Problems with deliberative systems

- `Reaction': *reactive systems*
- *Stimulus-response* approach
- No symbolic reasoning, no search
- No internal, symbolic representations
- *Layered / hierarchical* architecture

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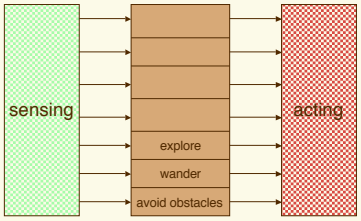
Subsumption architecture (Brooks 1991)



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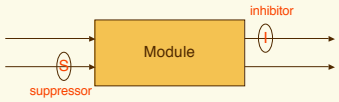
Subsumption architecture: (hard-wired) control by suppression and inhibition

- S: signal suppresses (and replaces) input into module for some pre-determined time
- I: signal inhibits output from module for some pre-determined time



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Hybrid systems

- Trying to *synthesize* both reactive and deliberative systems
- Typically (levels) *layered*: either *vertically* or *horizontally*

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Levels in hybrid systems

- Levels, e.g. *three-level* architecture:
  - Low-level: *'reflexes'* (e.g. servo control)
  - Intermediate level: *combines* low-level actions into more complex behaviors
  - High-level: *planning* (e.g. STRIPS planner)
- 'Classical' example: Shakey

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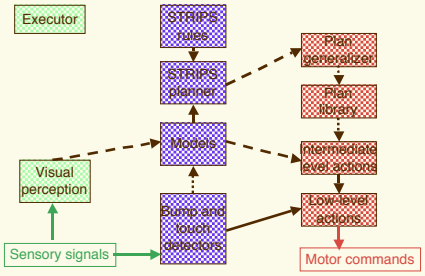
Shakey architecture (Nilsson 1984)



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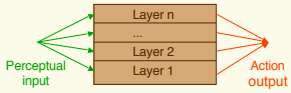
Layered hybrid systems

- *horizontally* or *vertically* layered



Horizontal layering

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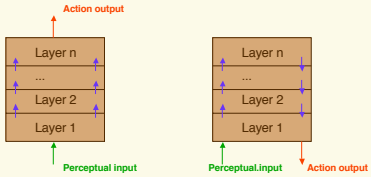
Layered hybrid systems (ctd)



Vertical layering
(1 pass control)

Vertical layering
(2 pass control)

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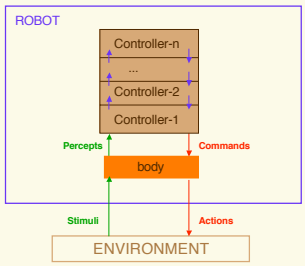
Hierarchical Robotic System Architecture (vertically layered)



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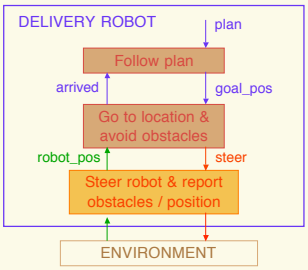
Example: Delivery Robot



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(Concrete) hybrid architectures

- TouringMachine (horizontally layered)
- InteRRaP (vertically layered)

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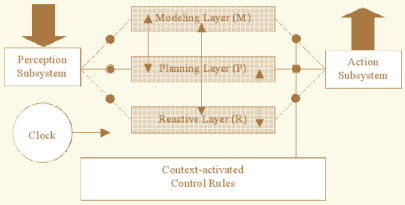
TouringMachine (Ferguson 1992)



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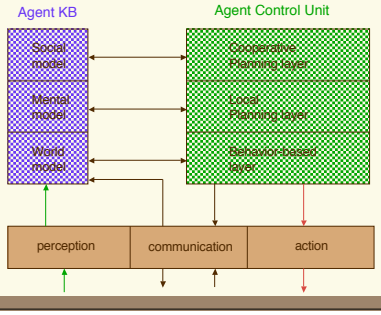
InteRRaP (Müller 1996)



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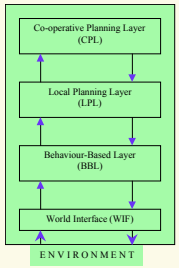
InteRRaP: agent control unit



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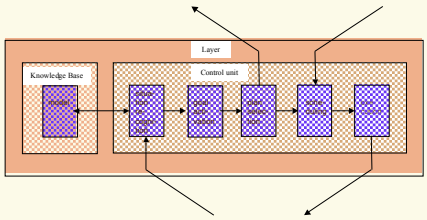
InteRRaP generic layer



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Kinds of hybrid systems (Arkin)

- Role of deliberation/planning in system:
  - Selecting lower-level actions/behaviors
  - Adapting lower-level actions/behaviors (smaller but more frequent modifications)
  - Advising lower-level actions (planner output competes with the lower-level actions)
  - Postponing reactivity by using the planner itself for generating reactions

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'Towers' in hybrid systems

- In hybrid systems there are *hierarchies* both on the *perception* and the *action* side (called *towers*, Albus)
- Nilsson observed that there is also a hierarchy in the *model* part: a third tower, thus obtaining the so-called *Triple Tower Architecture*

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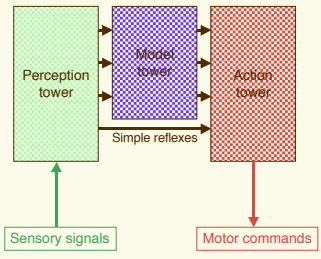
Triple-Tower Architecture



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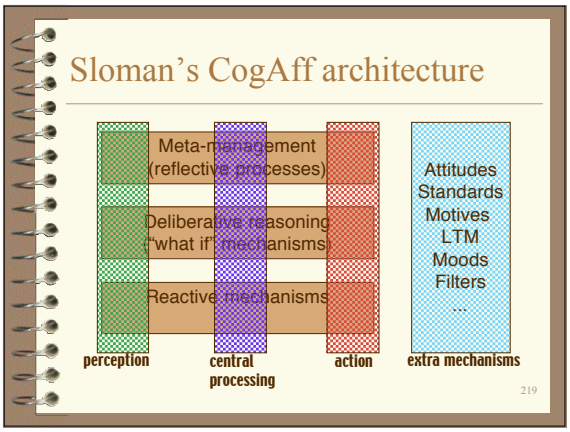
Sloman's CogAff architecture
Meta-management
(reflective processes)
Deliberative reasoning
("what if" mechanisms)
Reactive mechanisms
Attitudes
Standards
Motives
LTM
Moods
Filters
...
perception
central processing
action
extra mechanisms
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