

# BDI Model

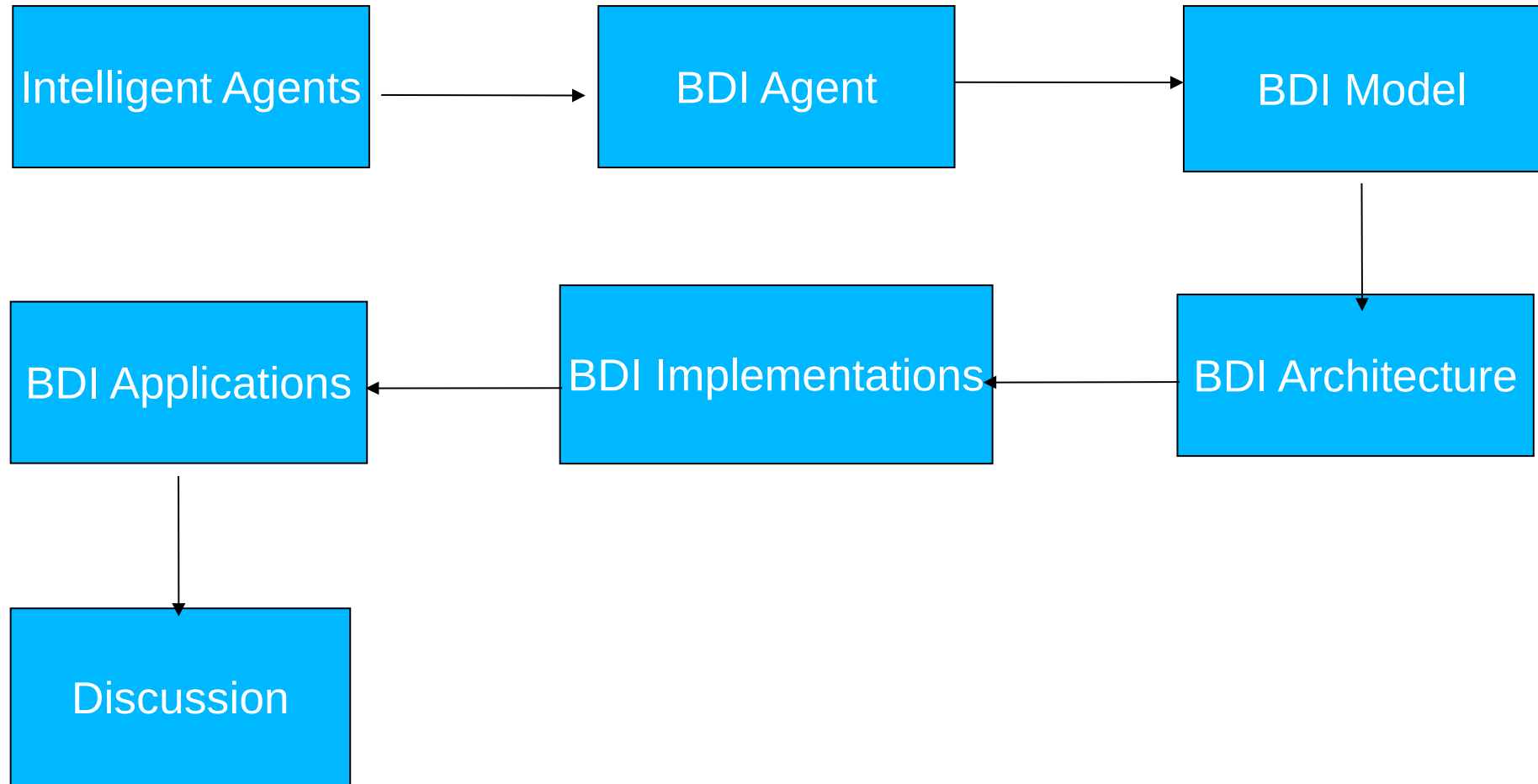
[Beliefs, Desires, Intentions]

Yuan Sun

Research lab – Summer term 2014

University Koblenz-Landau

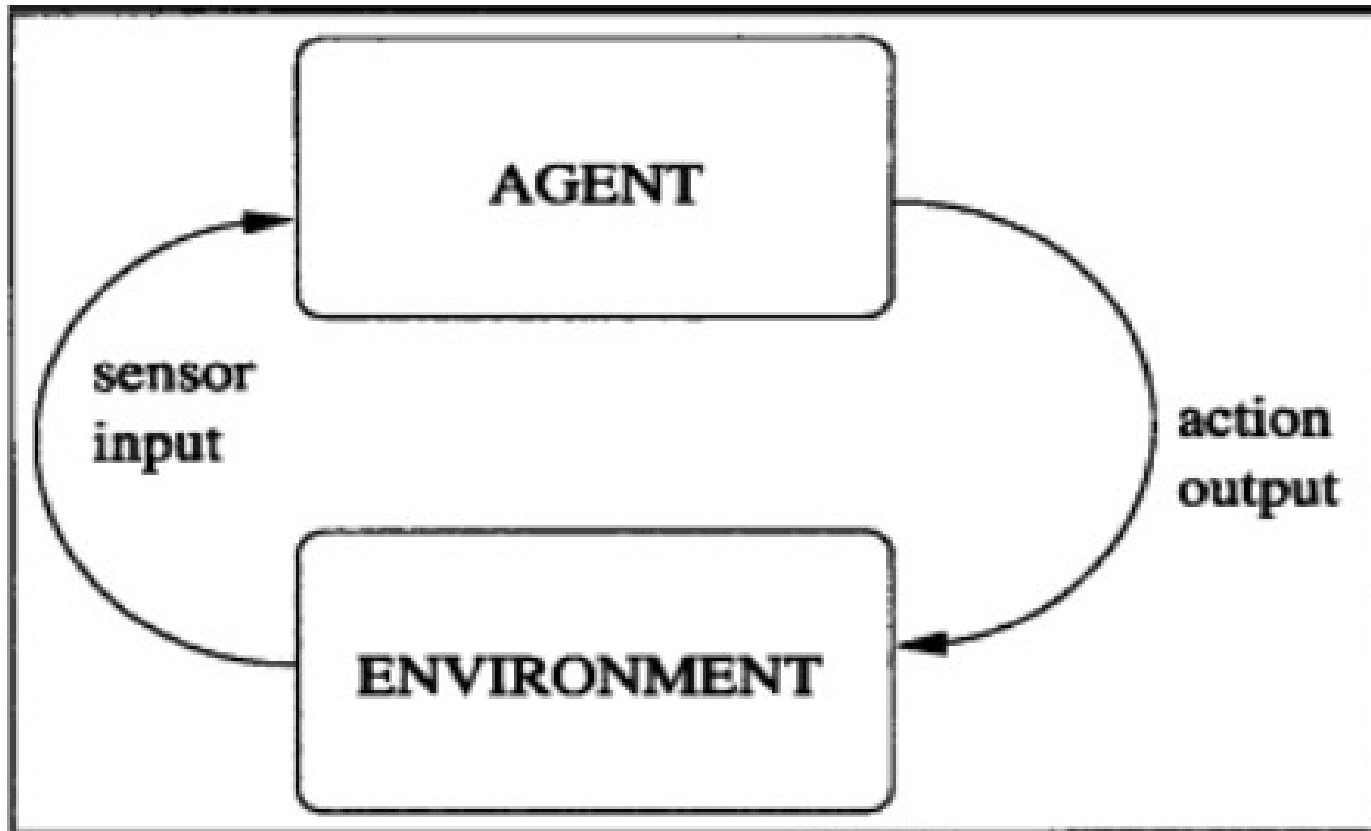
# Introduction



# Intelligent Agents

- "Agents" are autonomous, computational entities that can be viewed as perceiving their environment through sensors and acting upon their environment through effectors.
- "Intelligent" indicates that the agents pursue their goals and execute their tasks such that they optimize some given performance measures.

# Intelligent Agents



By Michael Wooldridge

# BDI agent

BDI agent is a kind of intelligent agents,  
which depending on BDI model:

*Beliefs,*

*Desires,*

*Intentions.*



Michael Bratman

*Originally developed by Michael Bratman*

# Beliefs

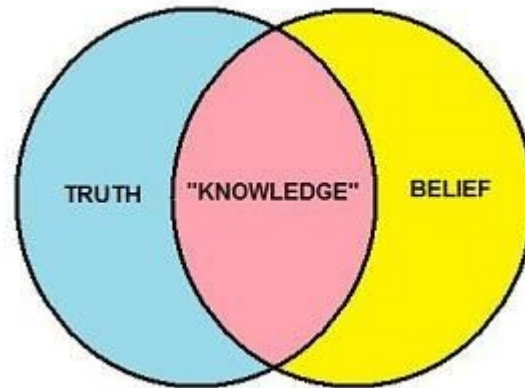
## *Beliefs:*

represent the informational state of the agent and be updated appropriately after each sensing action.

They may be implemented as a variable, a database, a set of logical expressions, or some other data structure.

# Beliefs

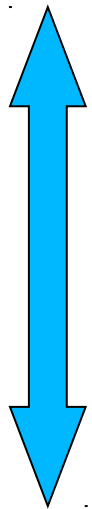
*Beliefs: are only required to provide information on the likely state of the environment*



*Knowledge: is the realization of a fact.*

# Desires

*Desires:* represent the motivational state of the agent. They represent objectives or situations agent would like to accomplish or bring about.



**Goals:** A goal is a desire that has been adopted for active pursuit by the agent.



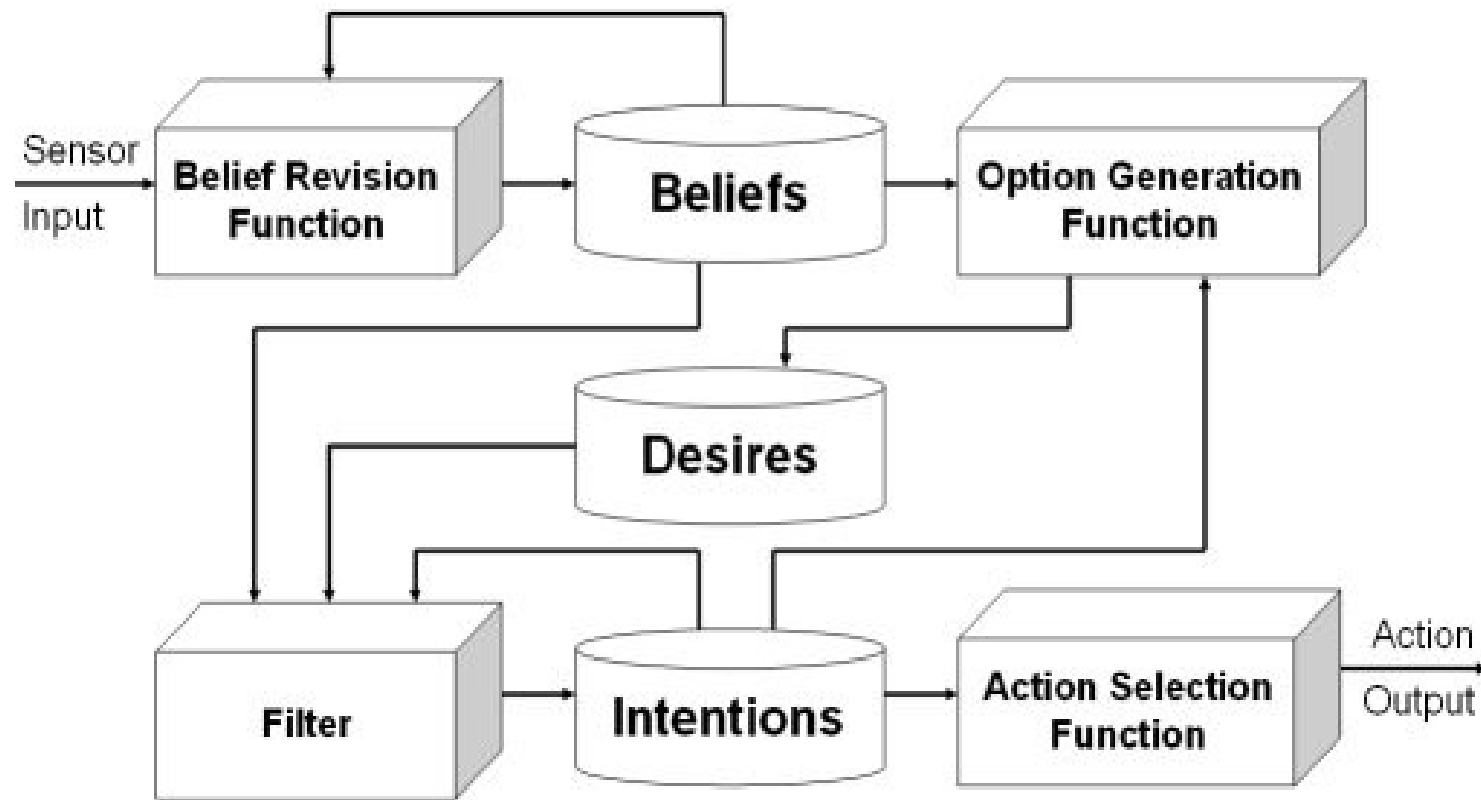
# Intentions:

## *Intentions:*

*Intentions are desires or actions that the agent has committed to achieve*

- Intentions drive means-ends reasoning.
- Intentions constrain future deliberation.
- Intentions persist.
- Intentions influence beliefs upon which future practical reasoning is based.

# Abstract BDI architecture



# Abstract BDI architecture

Table 1: Components of brief BDI agent architecture

Component	Meaning	Formalization
Beliefs set	Information about the current environment which the agent has	$B$
belief revision function	determines a new set of beliefs depending on perceptual inputs and the agents current beliefs	$B \times P \rightarrow B$
Options	determines desires depending on the agents current beliefs	$B \times I \rightarrow D$
Desires set	possible courses of actions available to the agent	$D$
Filter	determines the agents intentions depending on current beliefs, desires, and intentions	$B \times I \times D \rightarrow I$
Intentions set	the agents current focus	$I$
Action selection function	determines an action to perform depending on current intentions	$I \rightarrow A$

# Abstract BDI algorithm

```
1.
2.   $B := B_0;$ 
3.   $I := I_0;$ 
4.  while true do
5.    get next percept  $\rho;$ 
6.     $B := brf(B, \rho);$ 
7.     $D := options(B, I);$ 
8.     $I := filter(B, D, I);$ 
9.     $\pi := plan(B, I);$ 
10.   while not ( $empty(\pi)$ 
              or  $succeeded(I, B)$ 
              or  $impossible(I, B)$ ) do
11.      $\alpha := hd(\pi);$ 
12.      $execute(\alpha);$ 
13.      $\pi := tail(\pi);$ 
14.     get next percept  $\rho;$ 
15.      $B := brf(B, \rho);$ 
16.     if  $reconsider(I, B)$  then
17.        $D := options(B, I);$ 
18.        $I := filter(B, D, I);$ 
19.     end-if
20.     if not  $sound(\pi, I, B)$  then
21.        $\pi := plan(B, I)$ 
22.     end-if
23.   end-while
24. end-while
```

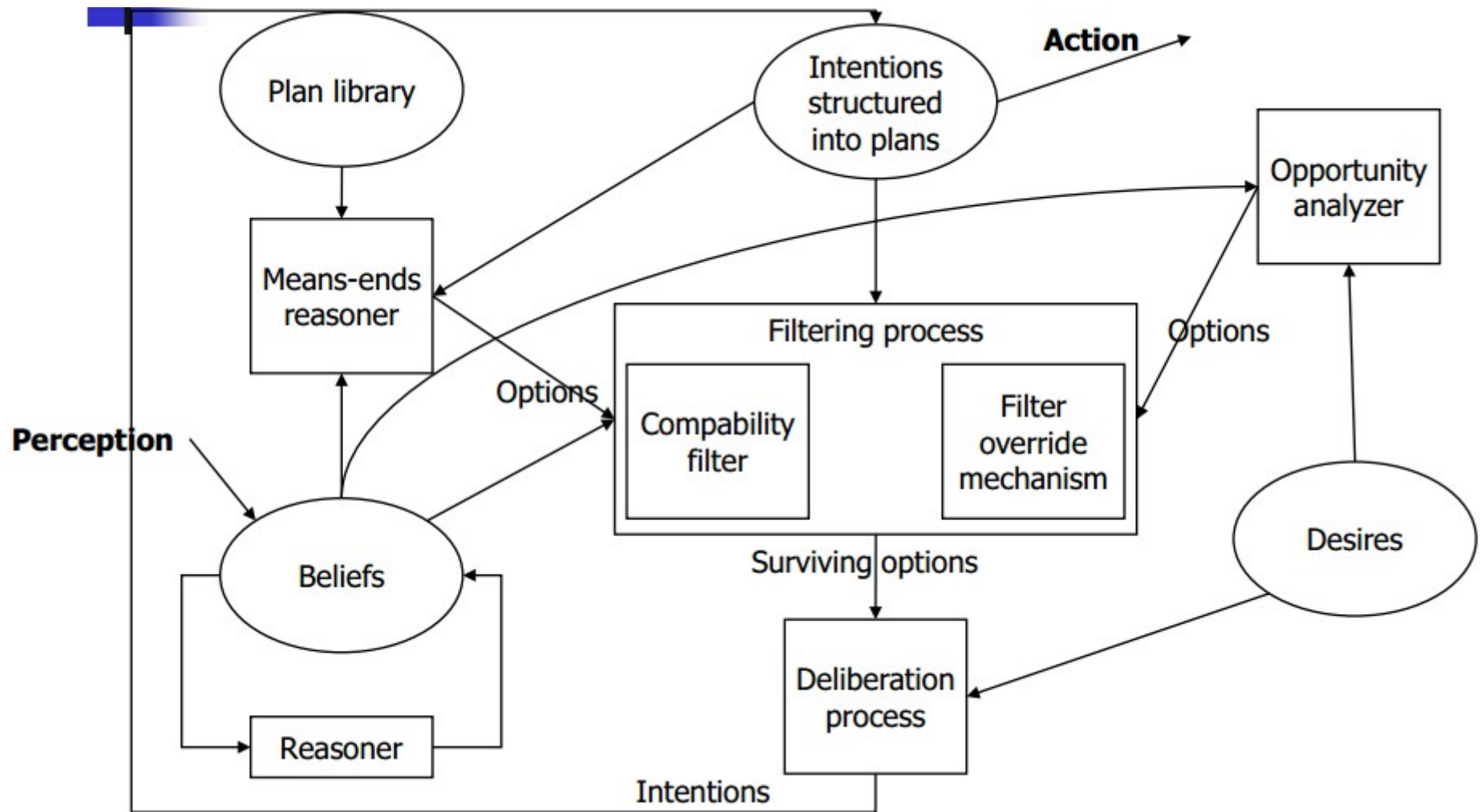
# Implementation-IRMA

*IRMA - Intelligent, Resource-Bounded Machine Architecture.*

*IRMA* - In 1988, was introduced by  
Bratman, Israel and Pollack

- the first system implementing  
the BDI

# IRMA architecture

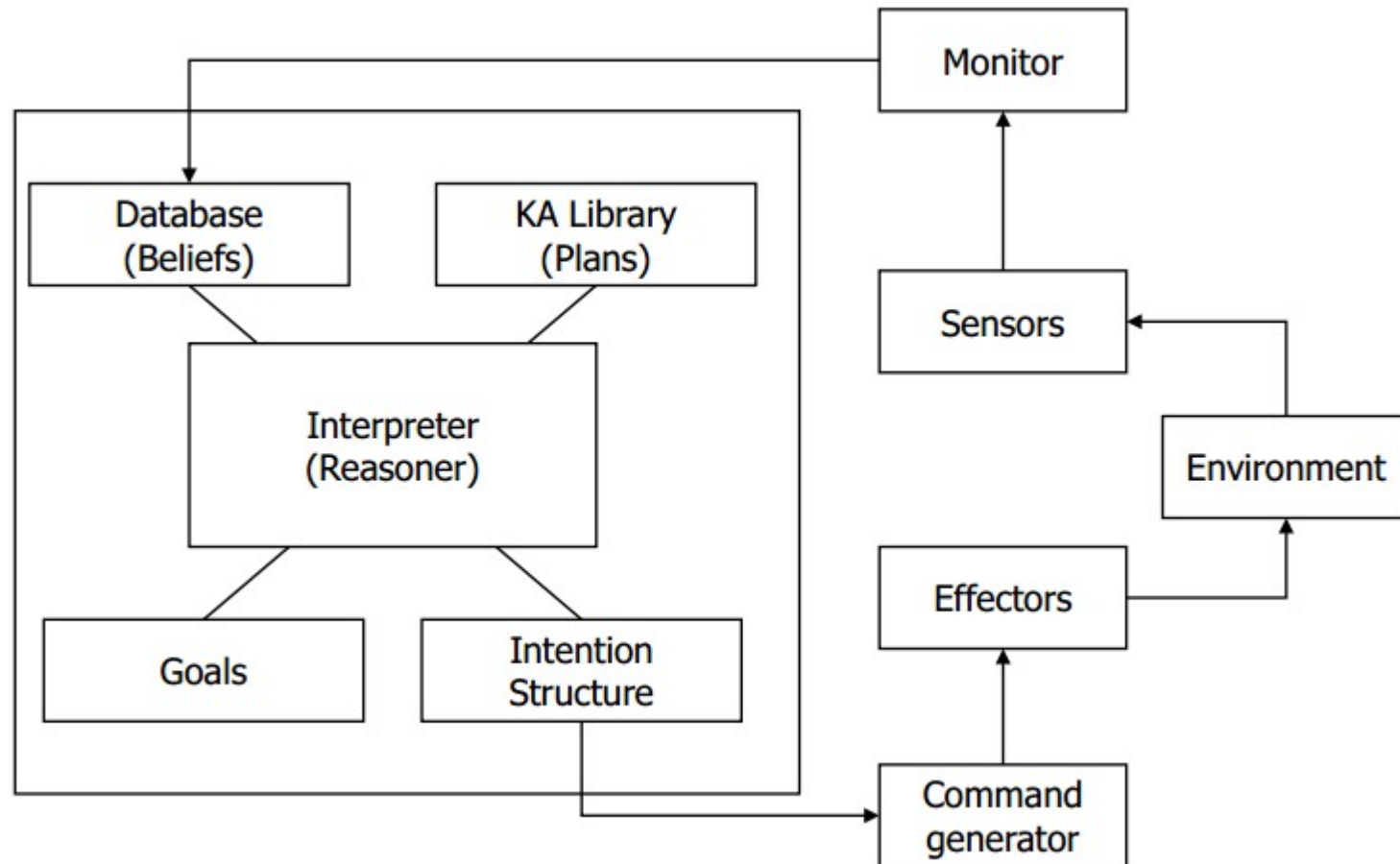


# Implementation-PRS

## *PRS - Procedural Reasoning System*

- developed by the Artificial Intelligence Center at SRI International during the 1980s
- The first application was a fault detection system for the reaction control system of the NASA Space Shuttle Discovery.

# PRS architecture



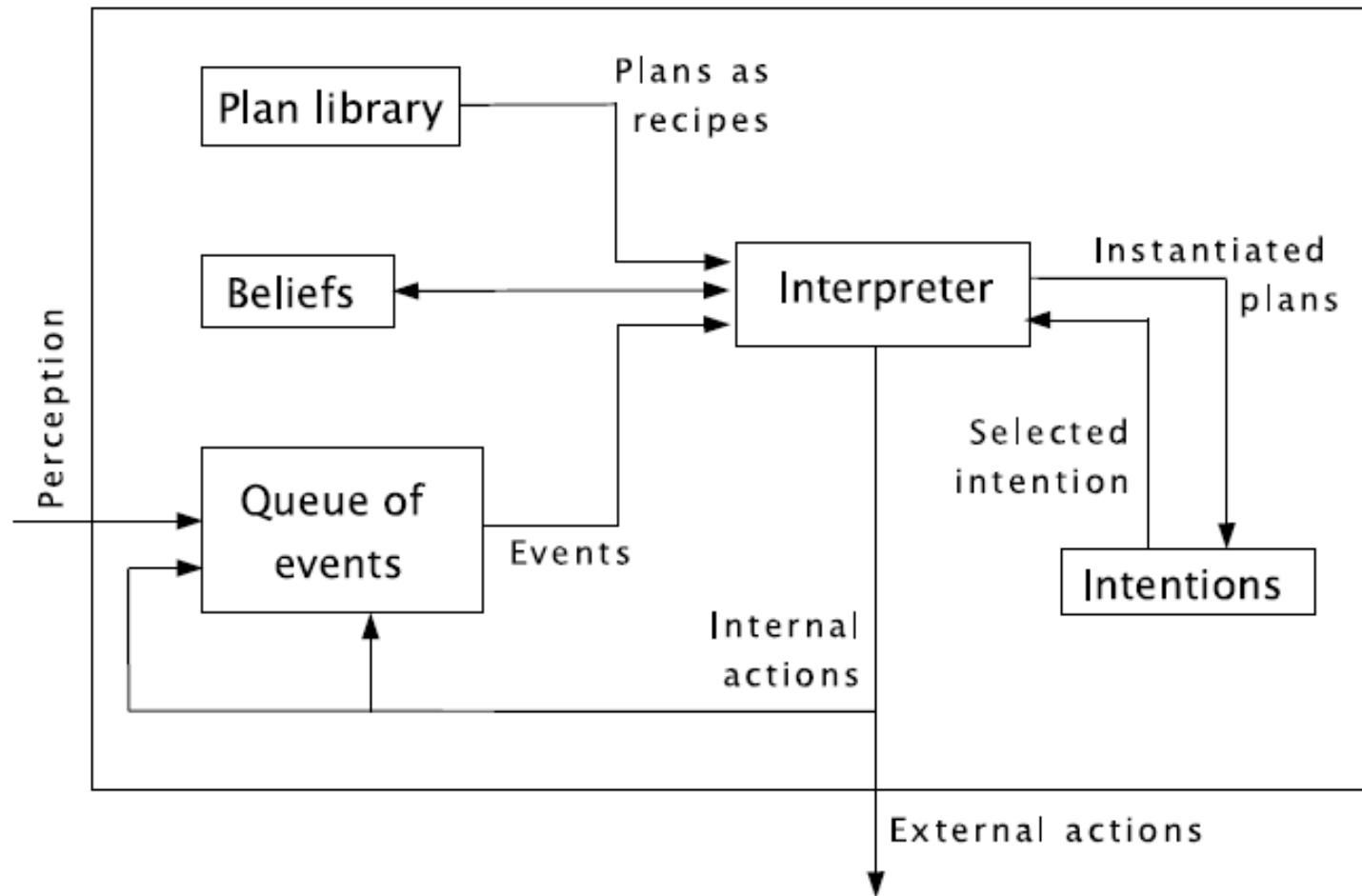


# Implementation-dMARS

*dMARS - Distributed multi-agent reasoning system*

- an extension of PRS;
- faster;
- more robust reimplementations

# dMARS architecture



# interpreter

initialize-state

repeat

options: option-generator (event-queue)

selected-options: deliberate (options)

update-intentions (selected-options)

execute()

end repeat

# BDI applications

*PRS and dMARS :*

fault detection system for the reaction control system of the NASA Space Shuttle Discovery.

*OASIS:*

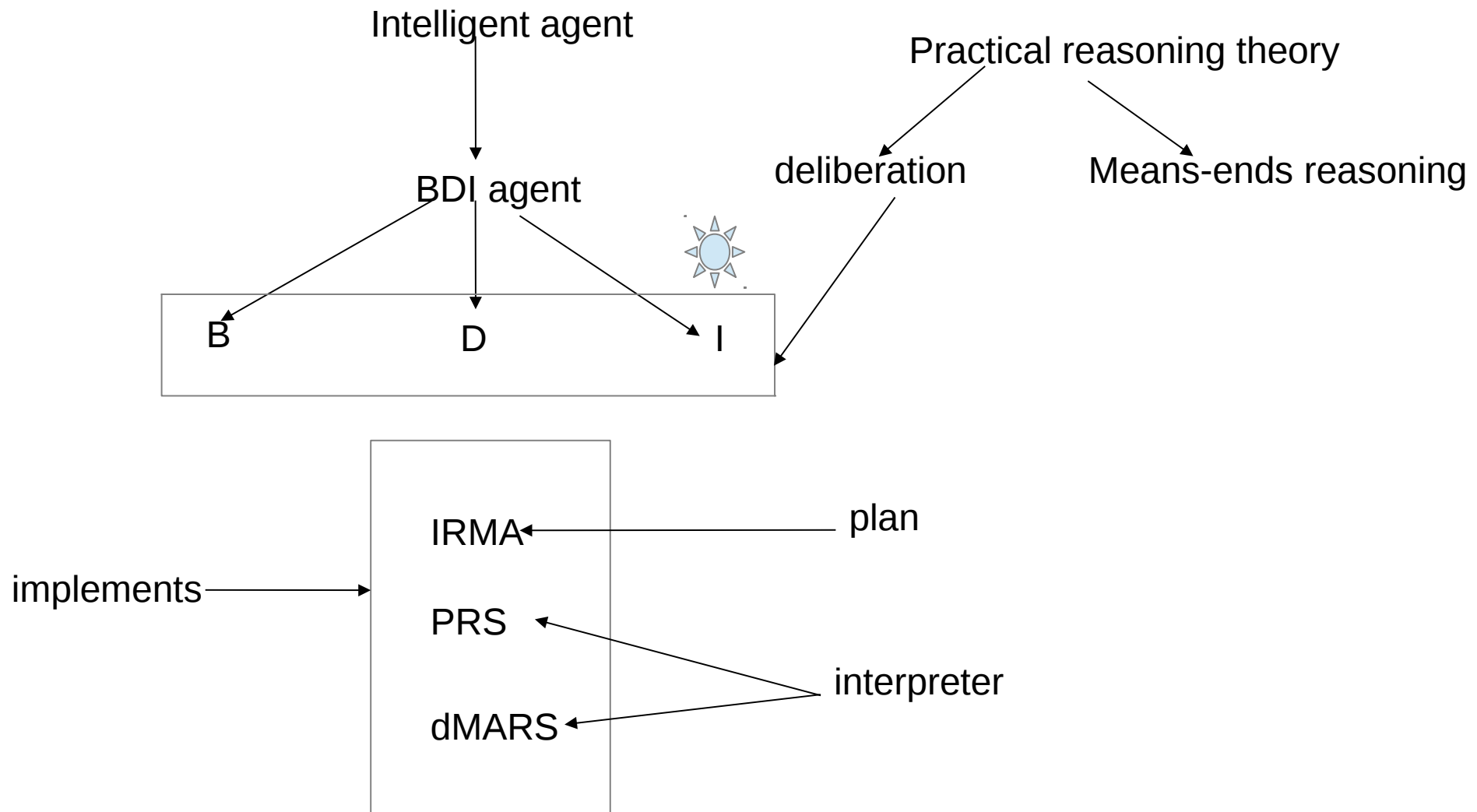
airline traffic management system



Robot Soccer:



# Summary



# Discussions

**Goals:** Most BDI implementations do not have an explicit representation of goals

**BDI Attitudes:** all three attitudes

- sufficient?
- necessary?

**Multiple Agents:** not explicit mechanisms for interaction and integration;

**Learning:** lack mechanisms to learn from past behavior or other agents' behavior

# References

- [1] Marvin Minsky The Society of Mind Simon Schuster, Inc, 399,1988. 2
- [2] Gerhard Weiss,editor Multiagent systems: a modern approach to distributed artificial intelligence. Library of Congress Cataloging-in-Publication Data, 1999. 2, 3, 3.2, 3.3
- [3] Michael Wooldridge, Nicholas R. Jennings. Intelligent Agents: Theory and Practice Knowledge Engineering Review,1995. 2
- [4] Stuart Russell. INTELLIGENT AGENTS ,31-52,1998. 2
- [5] Anand S. Rao, Michael P. George. BDI Agents: From Theory to Practice ,1995. 3.1, 3.2, 6
- [6] Henry Soldano Alejandro Guerra-Hernandez, Amal El Fallah-Seghrouchni. Learning in bdi multi-agent systems. Computational Logic in Multi-Agent Systems., 2004. 3.3, 5.3
- [7] Mrudula.K.Patkar. Review of Expert Systems for Newborns . , 2014. 2
- [8] MICHAEL GEORGEFF-DAVID KINNY MICHAEL WOOLDRIDGE MARK DINVERNO, MICHAEL LUCK. The dmars architecture: A specification of the distributed multi-agent reasoning system. Autonomous Agents and Multi-Agent Sytems, 9:5-53, 2004. 5.3
- [9] MARTHA POLLAC MICHAEL BRATMA, DAVIDJ. ISRAEL. Plans and resource-bounded practical reasoning. Comput. Intell, 4:349-355, 1988. 1, 5.1, 5.1
- [10] Martha Pollack-Milind Tambe Michael Wooldridge Michael Georgeff, Barney Pell. The belief-desire-intention model of agency.

# References

- 1] Francois Felix Ingrand Michael P. Georgeff. Decision-making in an embedded reasoning system. Proceedings of Eleventh International Joint Conference on Artificial Intelligence, August 1989. 5.2, 5.2, 5.37
- 2] Sebastian Sardina, Lavindra de Silva, Lin Padgham. Hierarchical Planning in BDI Agent Programming Language Formal Approach AAMAS '06 Proceedings of the fifth international joint conference on Autonomous agents and multiagent systems,2006. 3
- 3] James Delgrande. Revising by an Inconsistent Set of Formulas. Proceedings of the Twenty-Second International Joint Conference on Artificial Intelligence. 4.1.2
- 4] David N. Kinn y, Michael P. Georgeff. Commitment and Effectiveness of Situated Agents. Architectures and Languages. 4.3
- 5] Roberto Montagna, Giorgio Delzanno, Maurizio Martelli, Viviana Mascardi. BDIATL: An Alternating-time BDI Logic for Multiagent Systems. Proceedings of the Twenty-Second International Joint Conference on Artificial Intelligence. 4.1.6
- 6] Tom Holvoet. Agent architecture. 4.3
- 7] Belief revision,[http://en.wikipedia.org/wiki/Belief\\_revision](http://en.wikipedia.org/wiki/Belief_revision). 4.1.1, 4.1.2
- 8] Procedural reasoningsystem. 5.2
- system,[http://en.wikipedia.org/wiki/Procedural\\_reasoning\\_](http://en.wikipedia.org/wiki/Procedural_reasoning_system)
- 9] Distributed multi-agent reasoning system,[http://en.wikipedia.org/wiki/Distributed\\_multi-agent\\_reasoning\\_system](http://en.wikipedia.org/wiki/Distributed_multi-agent_reasoning_system)



# Thank you!

