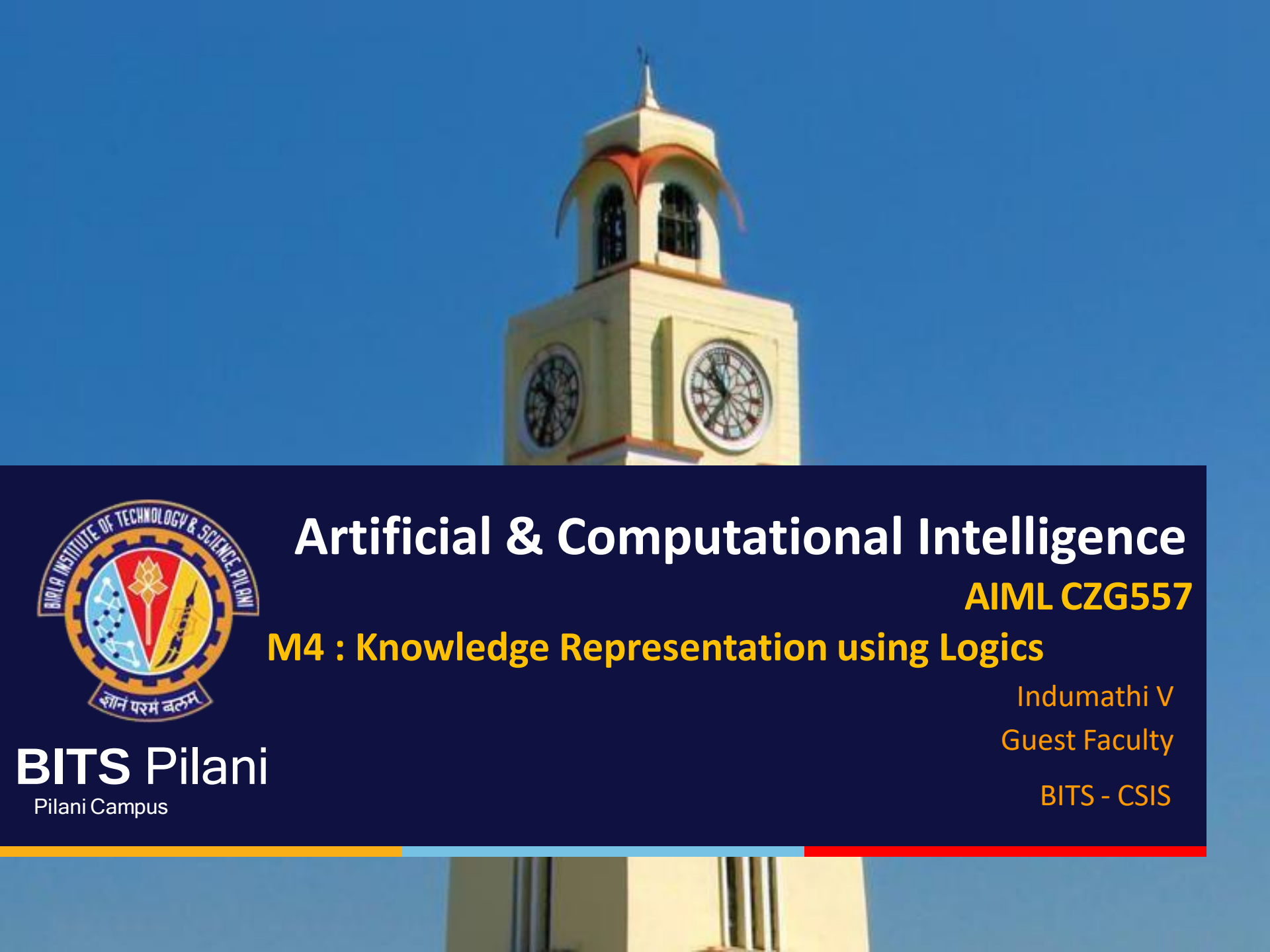


Artificial & Computational Intelligence

AIML CZG557

M4 : Knowledge Representation using Logics

Indumathi V

Guest Faculty

BITS - CSIS

BITS Pilani

Pilani Campus

Course Plan

M1 Introduction to AI

M2 Problem Solving Agent using Search

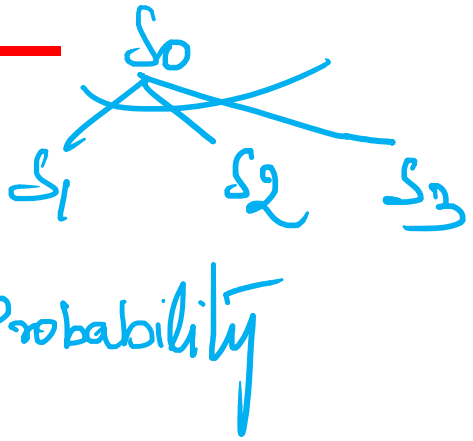
M3 Game Playing

M4 Knowledge Representation using Logics

M5 Probabilistic Representation and Reasoning

M6 Reasoning over time

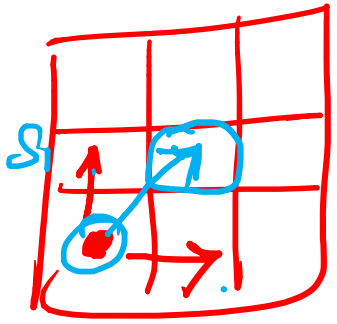
M7 Ethics in AI



certainty

Gaming (Imperfect Decisions)

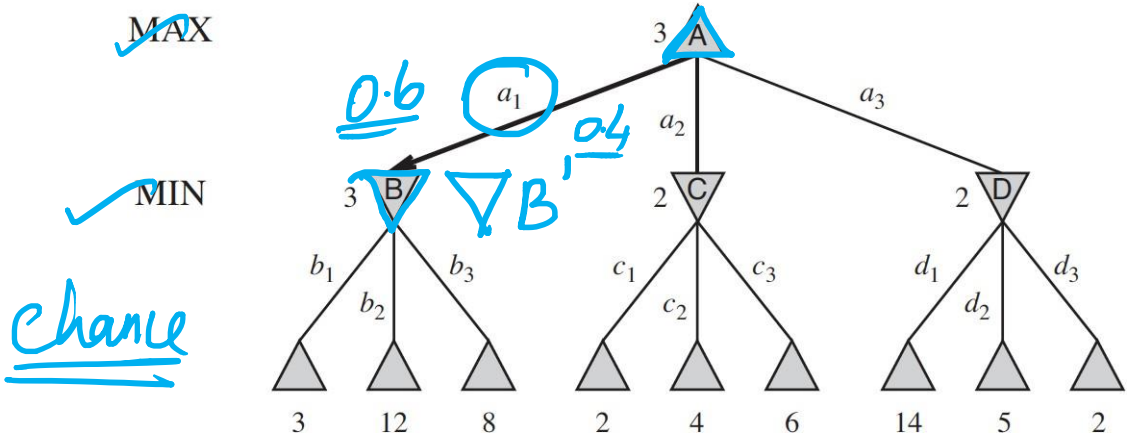
↓ → uncertainty



4 possible action

Computational Efficiency

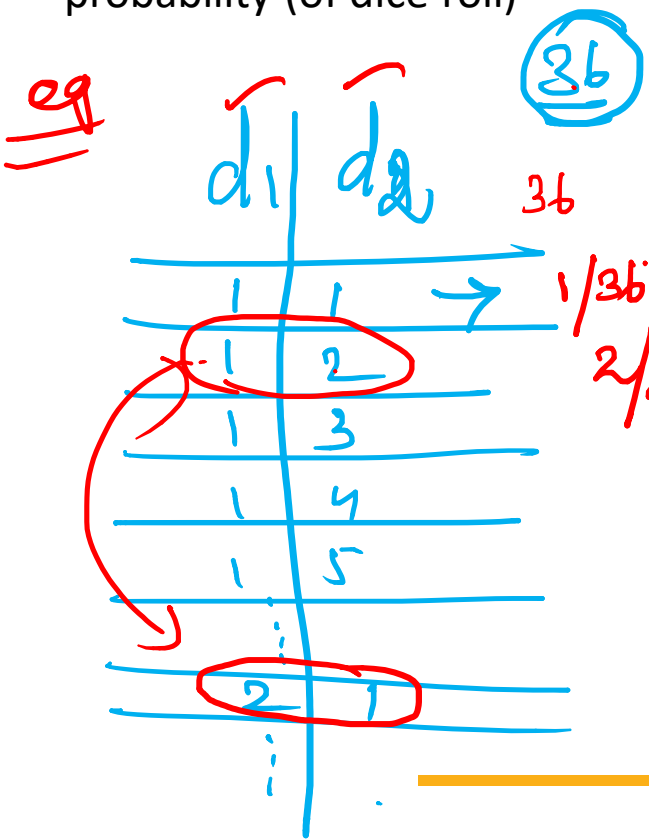
How games can be designed to handle imperfect decisions in real-time?

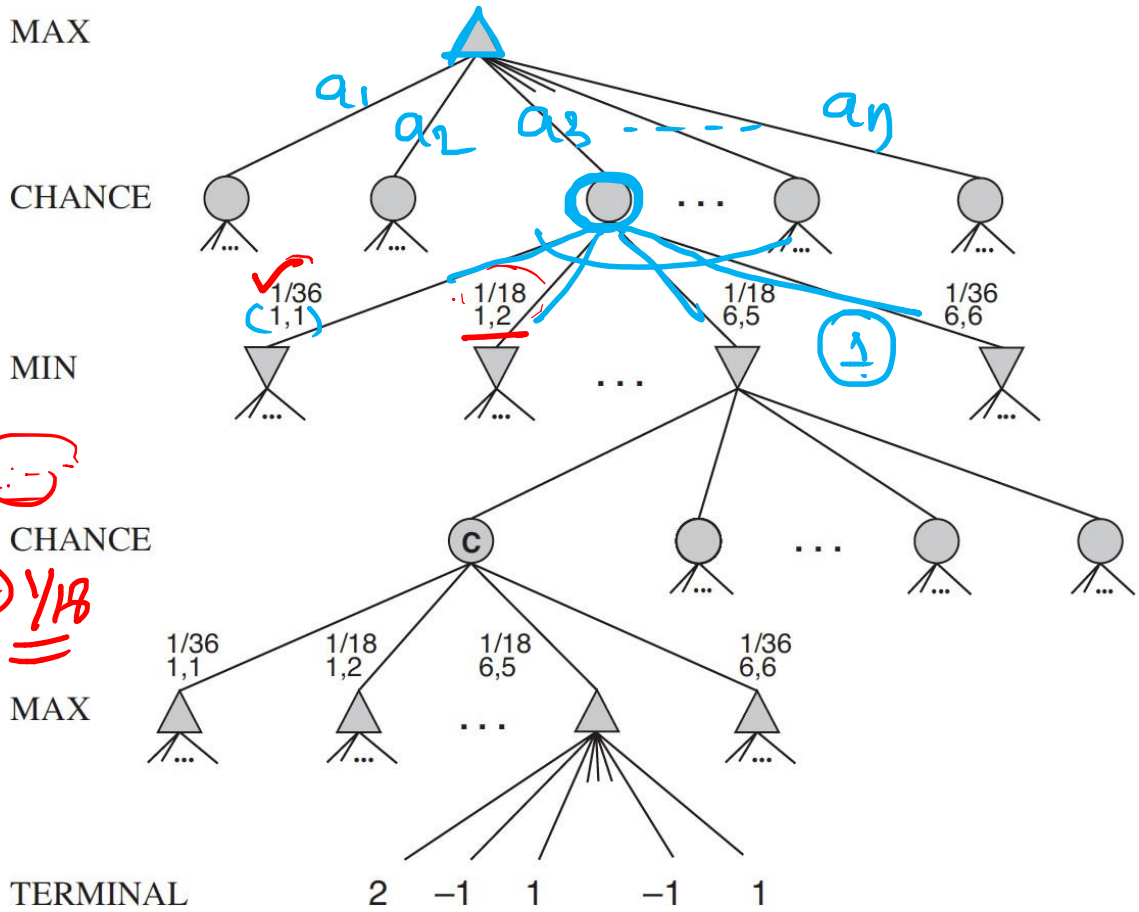


Computational Efficiency

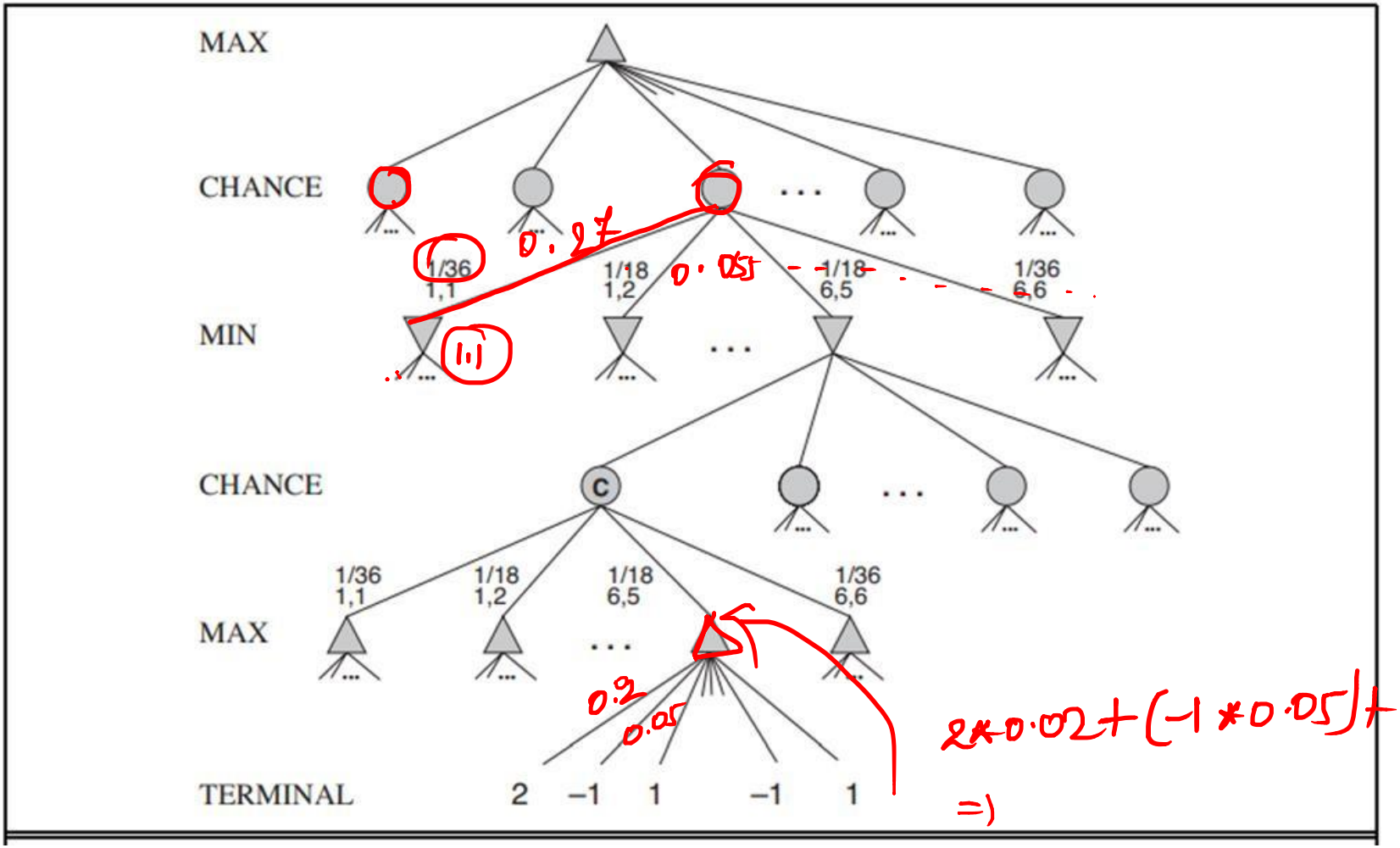
Idea : Chance Node:

Holds the expected values that are computed as a sum of all outcomes weighted by their probability (of dice roll)

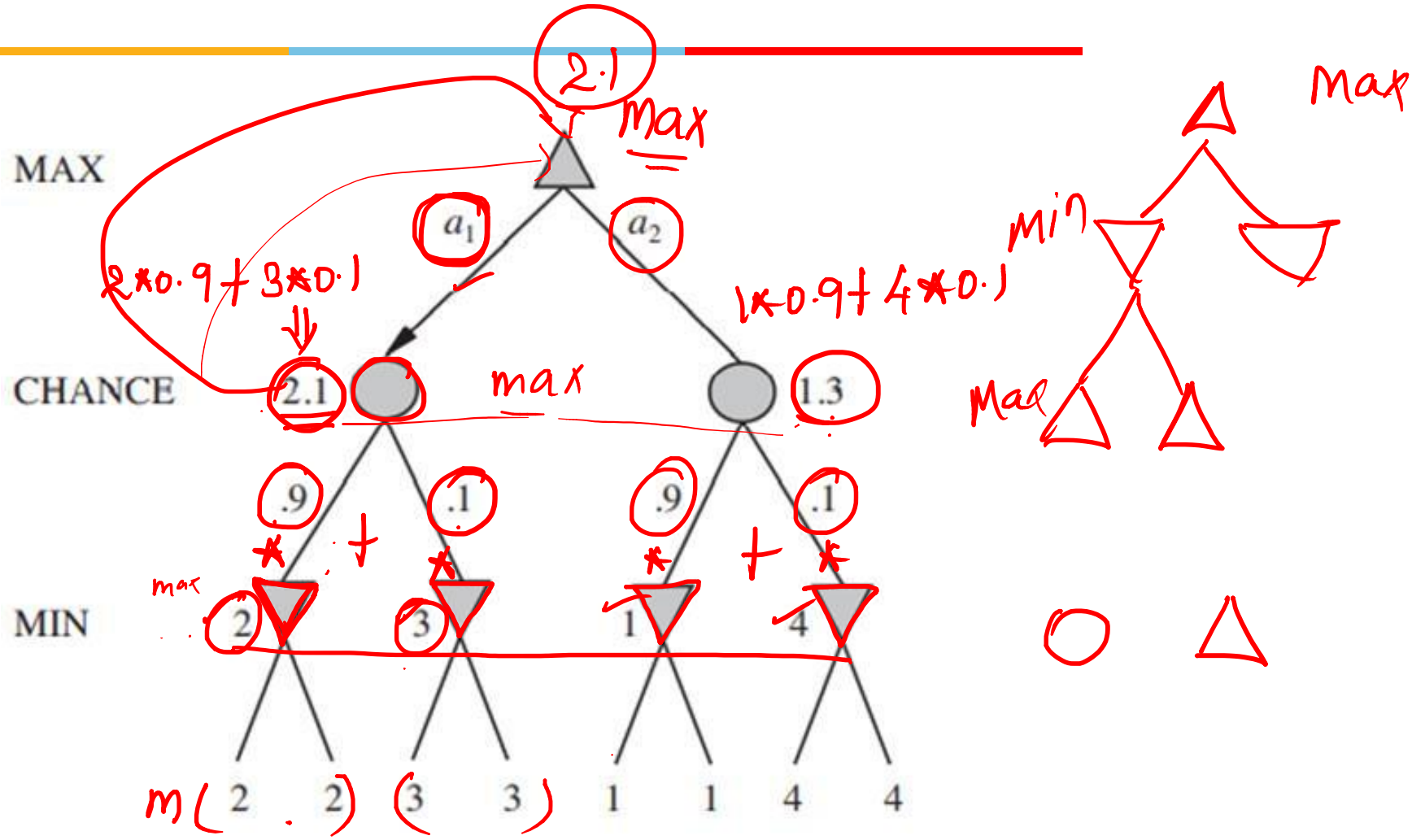


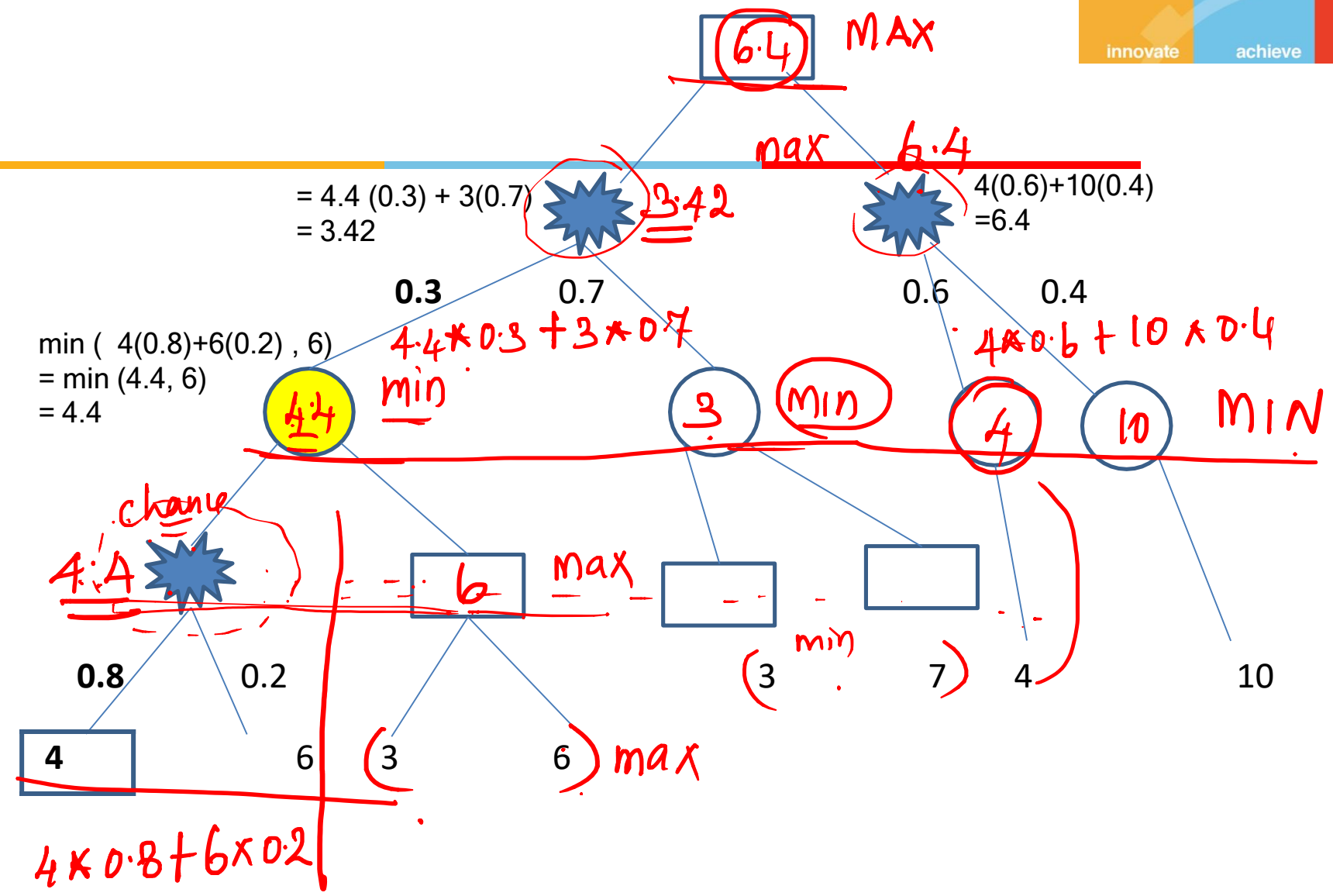


Expecti Mini Max Algorithm

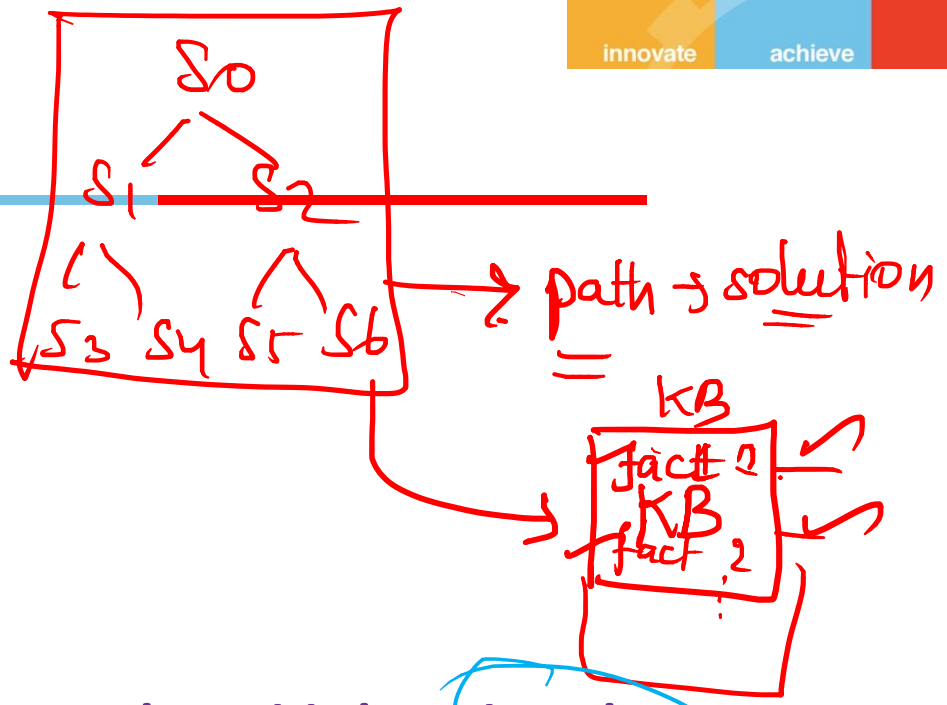


Expecti Minl Max Algorithm




6.4
MAX
max
6.4
= 4.4 (0.3) + 3(0.7)
= 3.42
3.42
4(0.6)+10(0.4)
=6.4
0.3
0.7
0.6
0.4
4.4*0.3+3*0.7
4*0.6+10*0.4
min (4(0.8)+6(0.2) , 6)
= min (4.4, 6)
= 4.4
min
4.4
3
min
4
10
MIN
change
4.4
6
max
0.8
0.2
3
min
7
4
10
4
6
3
6
max
4*0.8+6*0.2

1. uninformed Search
2. Informed "
3. Local "
4. Adversial Search



ML

Knowledge Representation Using Logics

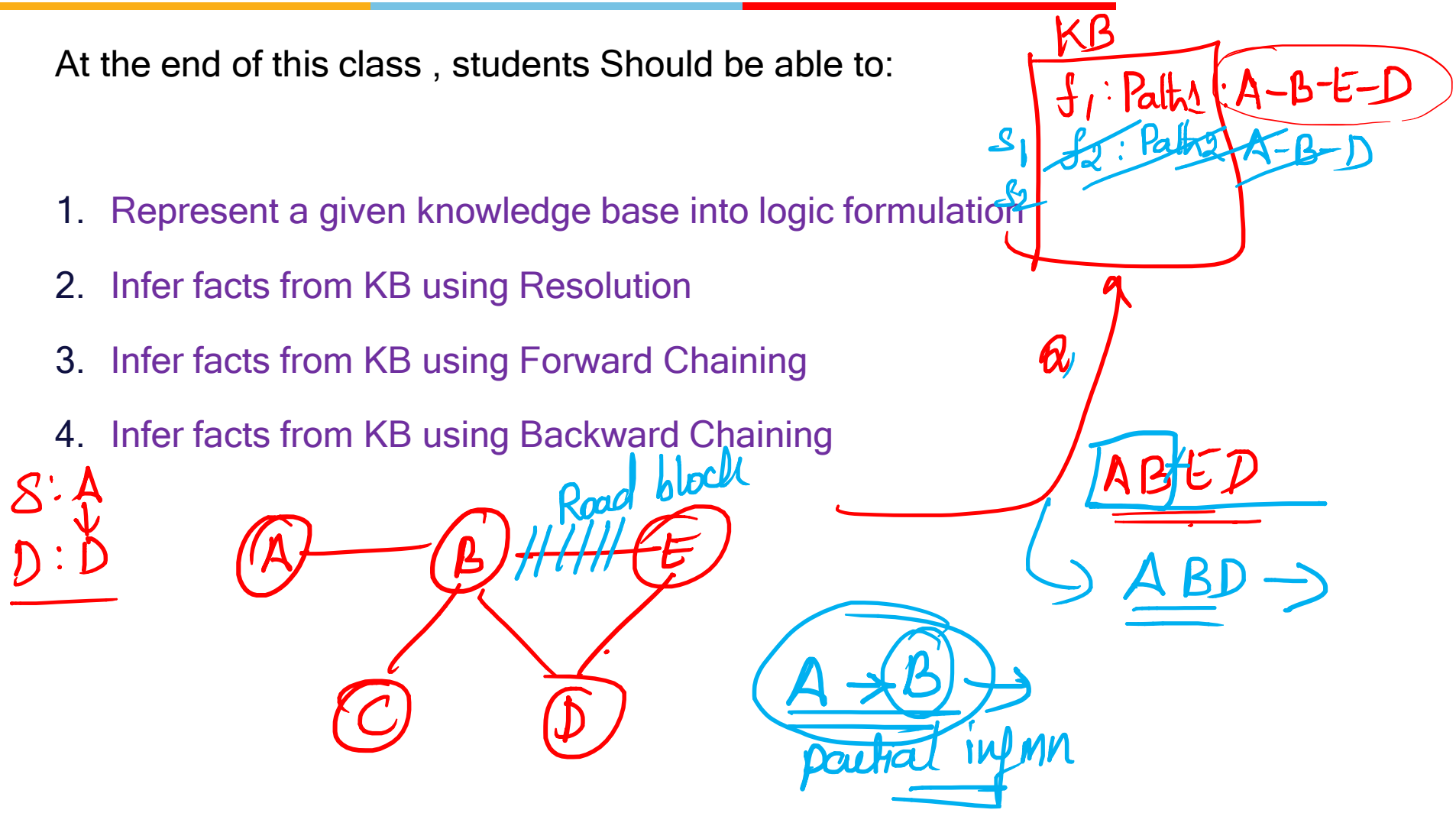
Large Prob → more info → generated → KB → Logon KB

A → B → Query → DB → result

Learning Objective

At the end of this class , students Should be able to:

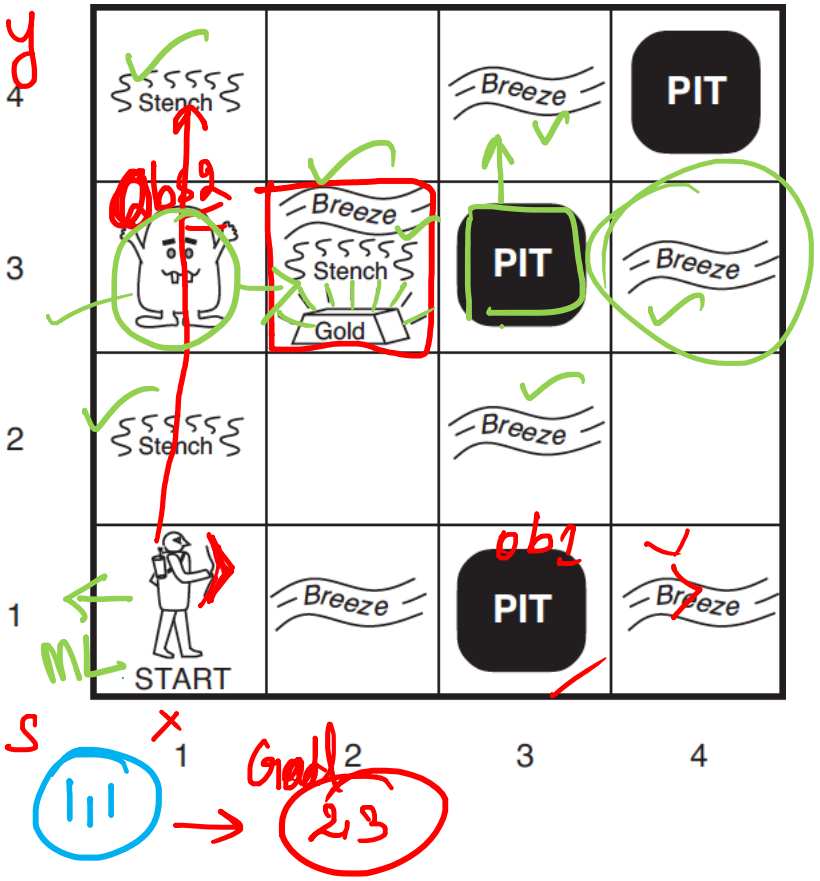
1. Represent a given knowledge base into logic formulation
2. Infer facts from KB using Resolution
3. Infer facts from KB using Forward Chaining
4. Infer facts from KB using Backward Chaining



Knowledge based Agent : Model & Represent

innovate achieve lead

Concepts, logic Representation of a sample agent



Wumpus World Problem:

PEAS:

Performance Measure:

+1000 for climbing out with gold,

-1000 for falling into a pit or being eaten by Wumpus,

-1 for each action taken and

-10 for using an arrow

Environment: 4x4 grid of rooms. Always starts at [1, 1] facing right.

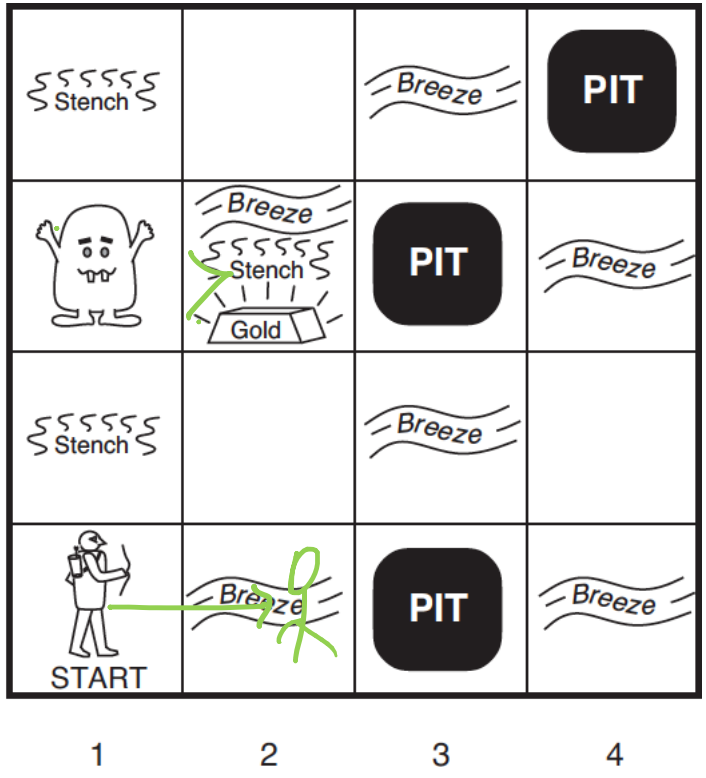
The location of Wumpus and Gold are random.

Agent dies if entered a pit or live Wumpus.

Knowledge based Agent : Model & Represent

innovate achieve lead

Concepts, logic Representation of a sample agent



Wumpus World Problem:

PEAS:

Actuators –

~~Forward~~,

~~Turn~~ Left by 90,

TurnRight by 90,

Grab – pick gold if present,

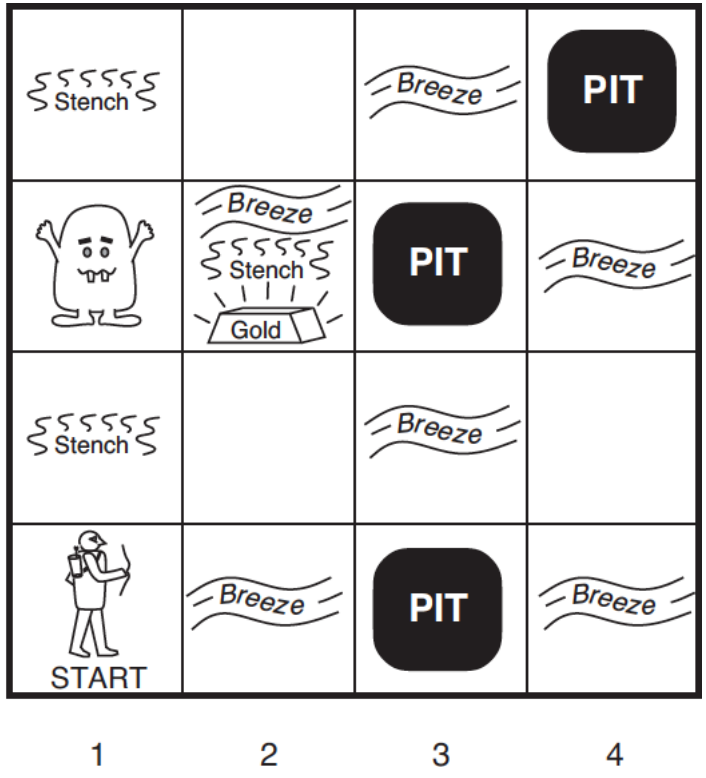
Shoot – fire an arrow, it either hits a wall or kills wumpus. Agent has only one arrow.

Climb – Used to climb out of cave, only from [1, 1]

Knowledge based Agent : Model & Represent

innovate achieve lead

Concepts, logic Representation of a sample agent

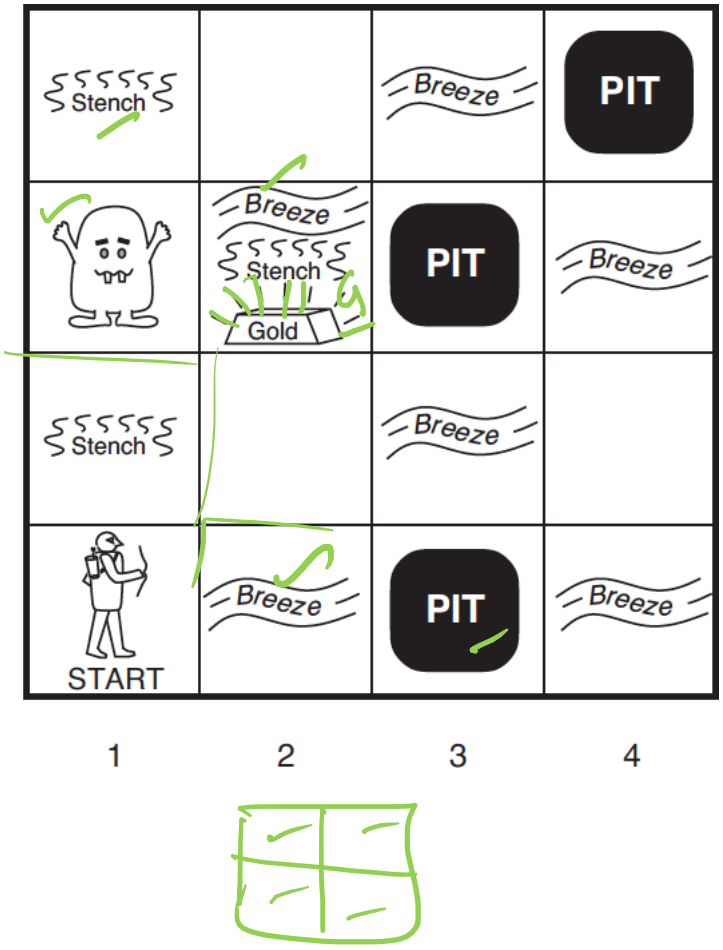


Why do we need Factored representation

- To reason about steps
- To learn new knowledge about the environment
- To adapt to changes to the existing knowledge
- Accept new tasks in the form of explicit goals
- To overcome partial observability of environment

Knowledge based Agent : Model & Represent

Concepts, logic Representation of a sample agent



Wumpus World Problem:

PEAS:

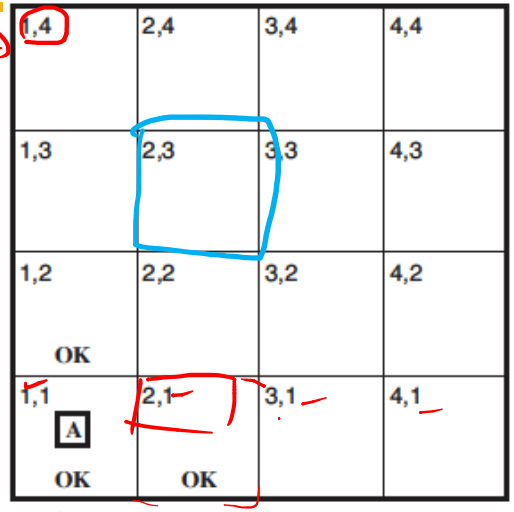
Sensors. The agent has five sensors

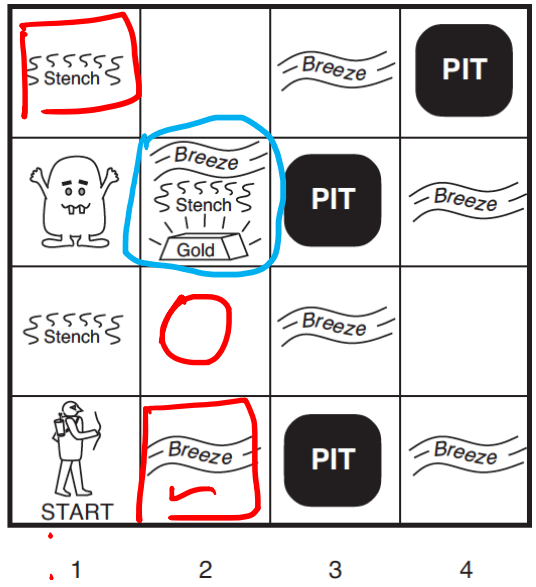
- **S**tench: In all adjacent (but not diagonal) squares of Wumpus
- **B**reeze: In all adjacent (but not diagonal) squares of a pit
- **G**litter: In the square where gold is
- **B**ump: If agent walks into a wall
- **S**cream: When Wumpus is killed, it can be perceived everywhere

Percept Format:
[Stench?, Breeze?, Glitter?, Bump?, Scream?]
E.g., [Stench, Breeze, None, None, None]

Percept 1: [None, None, None, None, None]

Action: Forward





B, S, G

Percepts ?

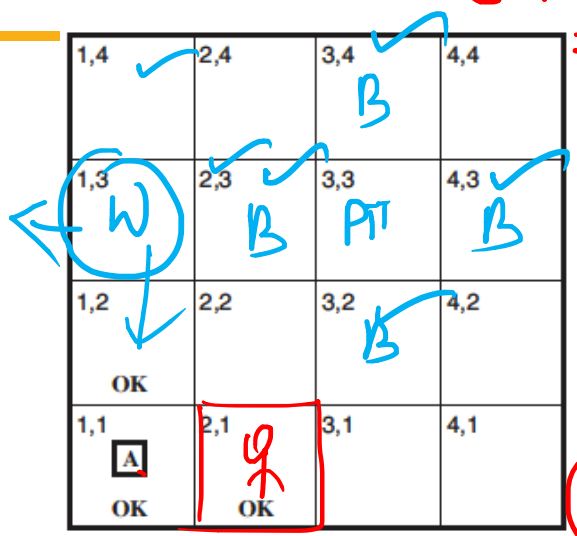
$L_{2,3} \rightarrow B_{23} \wedge S_{23} \wedge G_{23}$

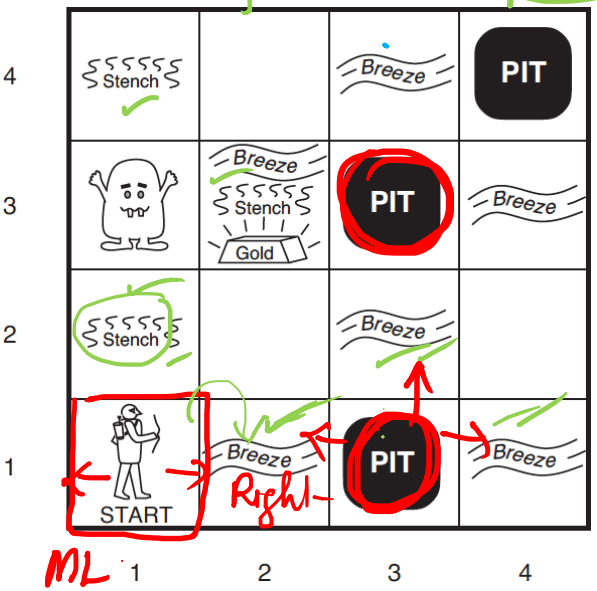
$L_{2,1} \rightarrow B_{21} \wedge \neg S_{21} \wedge \neg G_{21}$

Percept Format:
[Stench?, Breeze?, Glitter?, Bump?, Scream?]

Percept 1: [None, None, None, None, None]

Action: Forward

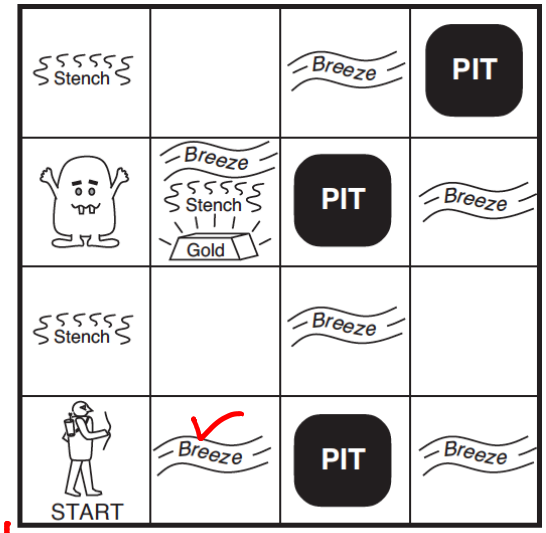




Percept 1: [None, None, None, None, None]

Action: Forward

1,4	2,4	3,4	4,4
1,3	2,3	3,3	4,3
1,2 OK	2,2	3,2	4,2
1,1 A OK	2,1 OK	3,1	4,1



$B_{x,y} \rightarrow P_{x+1,y} \vee P_{x,y+1} \vee P_{x-1,y} \vee P_{x,y-1}$ OR

$S_{x,y} \rightarrow W_{x+1,y} \vee W_{x,y+1} \vee W_{x-1,y} \vee W_{x,y-1}$

$\neg B_{11} \rightarrow \neg P_{12} \wedge \neg P_{21}$

$\neg S_{11} \rightarrow \neg W_{12} \wedge \neg W_{21}$

Rule 3

Rule 4

deduced facts

PIT free

monster free

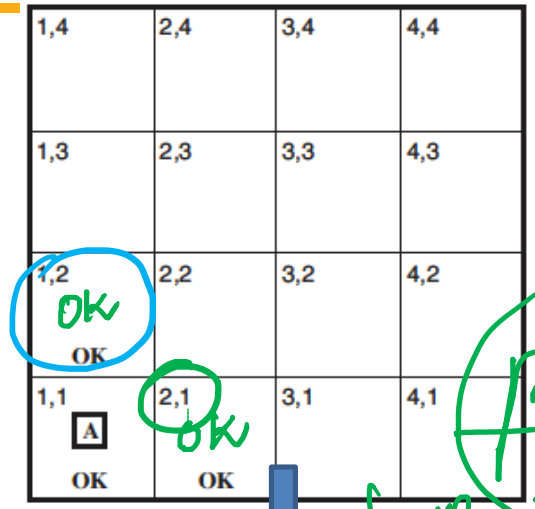
Safe cell

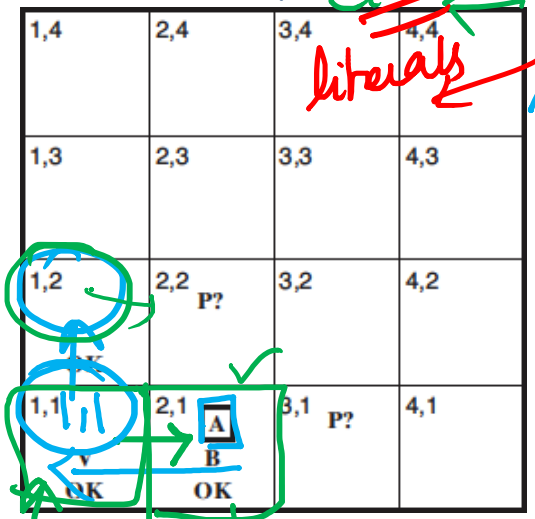
Percept Format:
[Stench?, Breeze?, Glitter?, Bump?, Scream?]

Percept 3: [Stench, ~~None~~, ~~None~~, ~~None~~, ~~None~~] Breeze

Action: Move to [2, 2]

Remembers (2,2) as possible PIT and no Stench.





fact

$Loc_{2,1} \Rightarrow B_{21} \wedge \sim S_{21}$

$B_{21} \rightarrow P_{11} \vee P_{22} \vee P_{31}$

$\sim S_{21} \rightarrow \sim W_{11} \wedge \sim W_{22} \wedge \sim W_{31}$

clause

literals

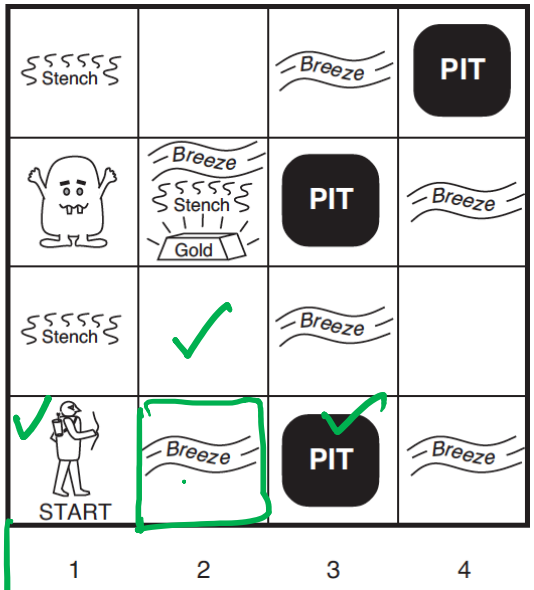
$P_{11} \vee P_{22} \vee P_{31}$

KB

$\sim P_{11}$

$P_{22} \vee P_{31}$

2 < Risk → Randomly
backtrack → alternate path.

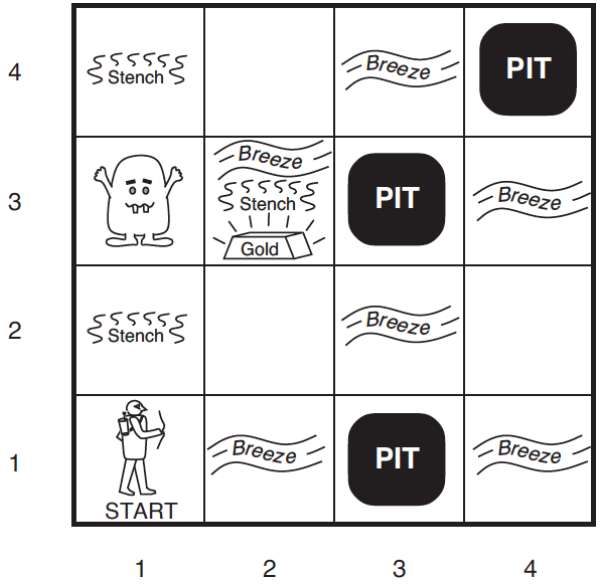


KB

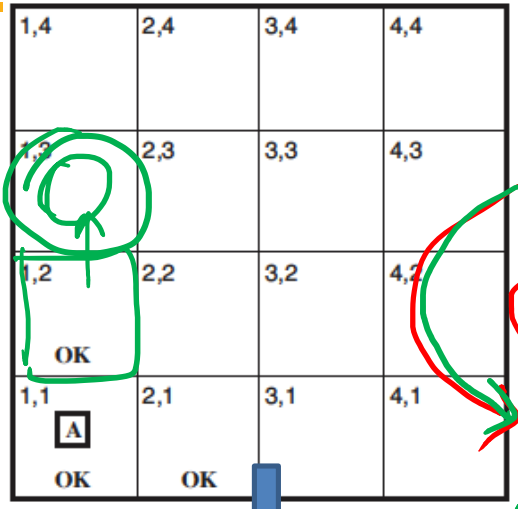
Percept 3: [Stench, None, None, None, None]
Action: Move to [2, 2]
Remembers (2,2) as possible PIT and no Stench.

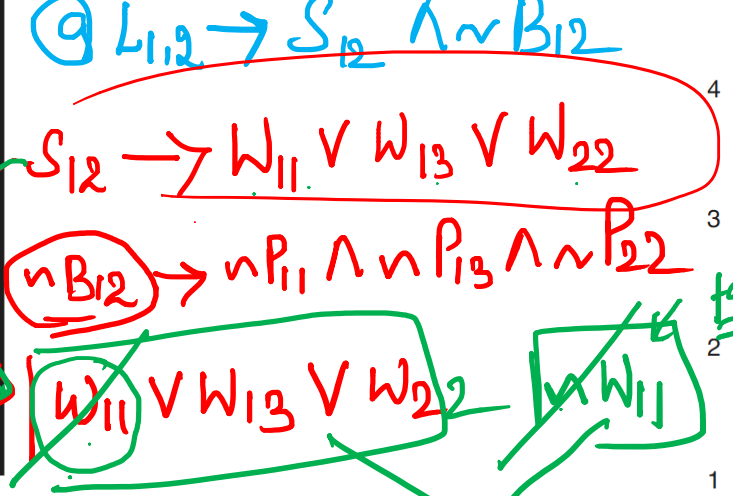
1,4	2,4	3,4	4,4
1,3	2,3	3,3	4,3
1,2 OK	2,2	3,2	4,2
1,1 A OK	2,1 OK	3,1	4,1

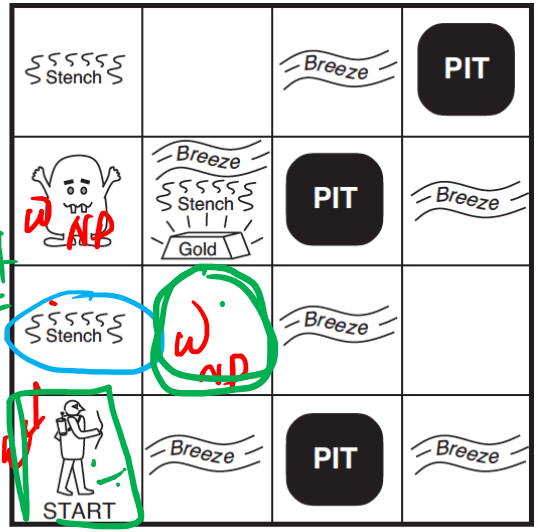
1,4	2,4	3,4	4,4
1,3	2,3	3,3	4,3
1,2 OK	2,2 P?	3,2	4,2
1,1 V OK	2,1 A B OK	3,1 P?	4,1

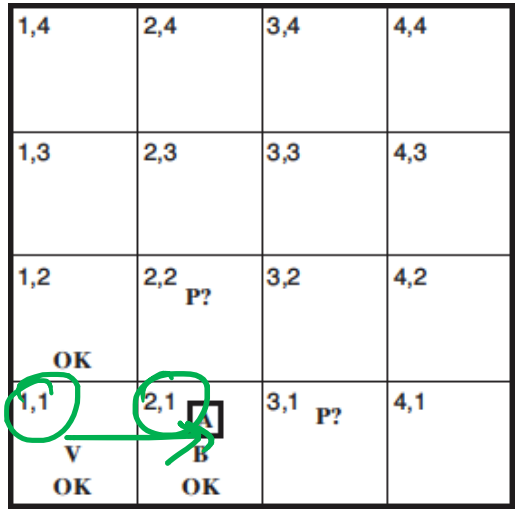


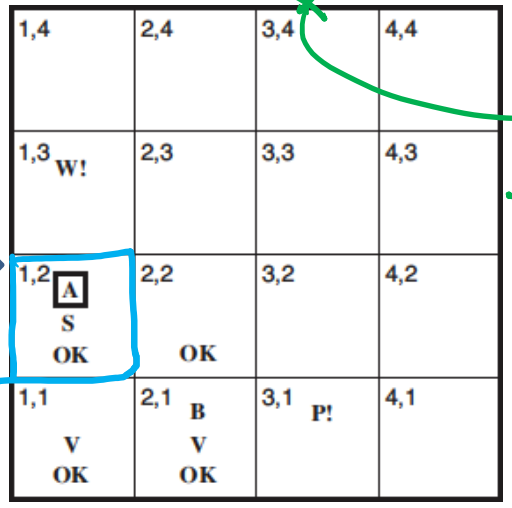
Percept 3: [Stench, None, None, None, None]
Action: Move to [2, 2]
Remembers (2,2) as possible PIT and no Stench.

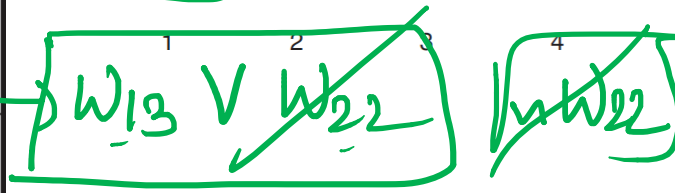


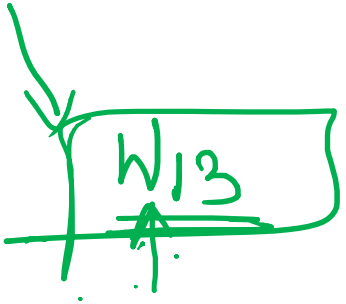




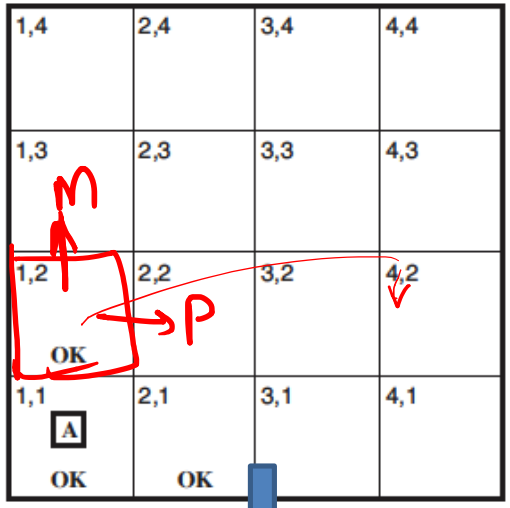


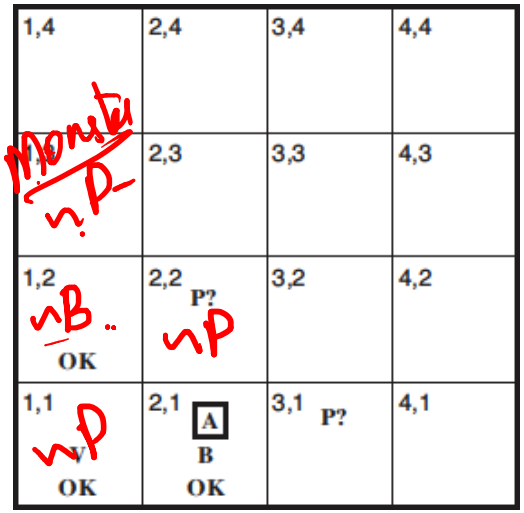


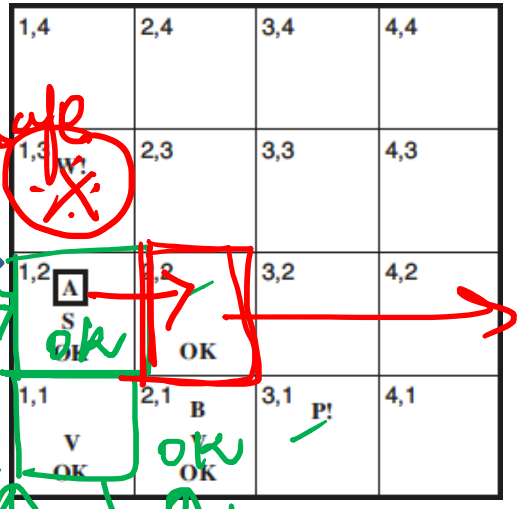


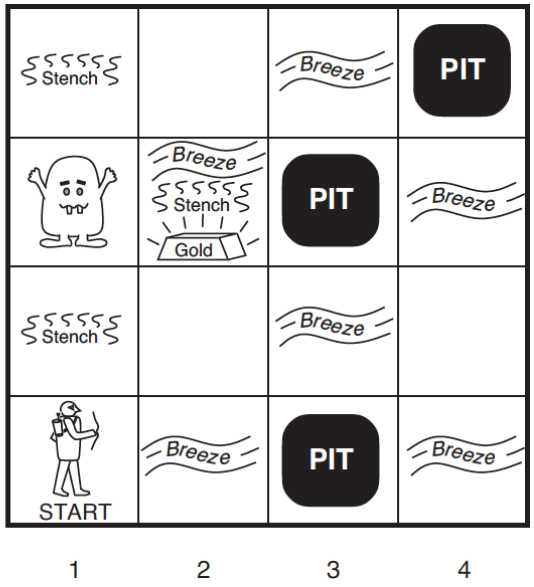


Percept 3: [Stench, None, None, None, None]
Action: Move to [2, 2]
Remembers (2,2) as possible PIT and no Stench.







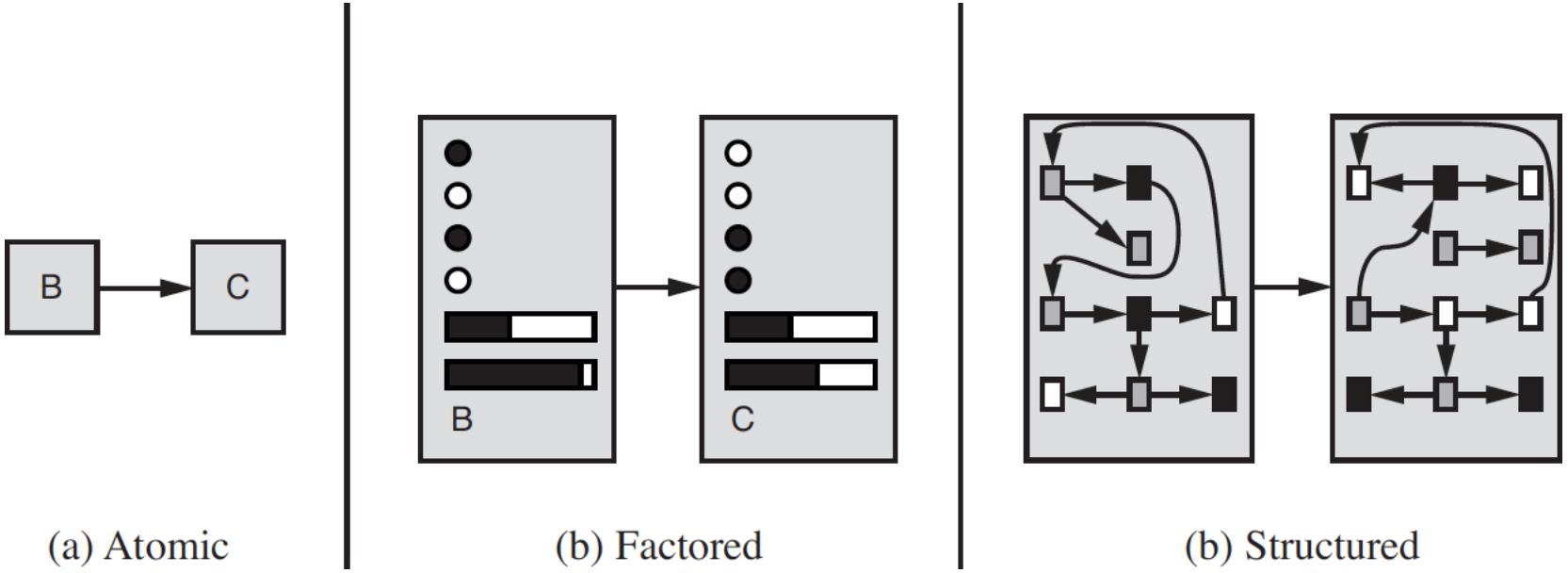


Representation

Agents based on Propositional logic, TT-Entail for inference from truth table

Syntax
Semantics
Model

→ Logic → Propositional Logic
→ Predicate Logic



Search Strategies | Propositional Logic | First Order Logic

Propositional Logic

innovate achieve lead

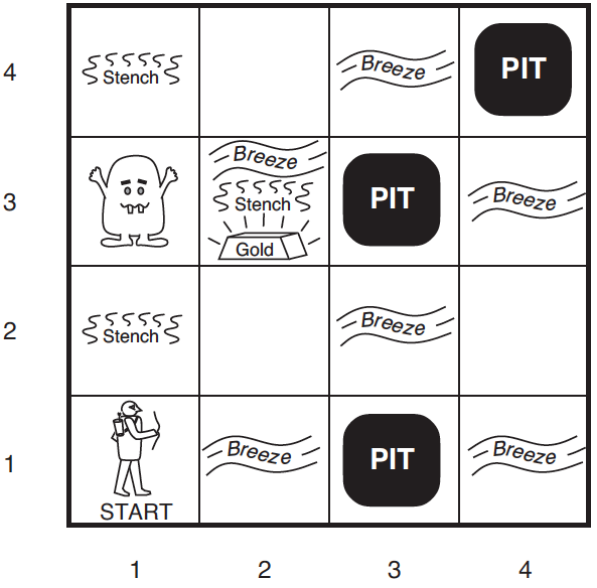
Agents based on Propositional logic, TT-Entail for inference from truth table

A simple representation language for building knowledge-based agents

Proposition Symbol - A symbol that stands for a proposition.
E.g., W1,3 - "Wumpus in [1,3]" is a proposition and $W_{1,3}$ is the symbol
Proposition can be true or false

Atomic : $W_{1,3}$
Conjuncts : $W_{1,3} \wedge P_{3,1}$
Disjuncts : $W_{1,3} \vee P_{3,1}$
Implications :
$(W_{1,3} \wedge P_{3,1}) \Longrightarrow \neg W_{2,2}$
Biconditional : $W_{1,3} \Leftrightarrow \neg W_{2,2}$

1,4	2,4	3,4	4,4
1,3	2,3	3,3	4,3
1,2 OK	2,2	3,2	4,2
1,1 A OK	2,1 OK	3,1	4,1



Propositional Logic

Agents based on Propositional logic ,TT-Entail for inference from truth table

Tie break in search:

$\neg$, $\wedge$, $\vee$, $\Rightarrow$, $\Leftrightarrow$

$(\neg A) \wedge B$ has precedence over $\neg (A \wedge B)$

P	Q	$\neg P$	$P \wedge Q$	$P \vee Q$	$P \Rightarrow Q$	$P \Leftrightarrow Q$
false	*false*	*true*	*false*	*false*	*true*	*true*
false	*true*	*true*	*false*	*true*	*true*	*false*
true	*false*	*false*	*false*	*true*	*false*	*false*
true	*true*	*false*	*true*	*true*	*true*	*true*