# AND-OR Graph and Wumpus World

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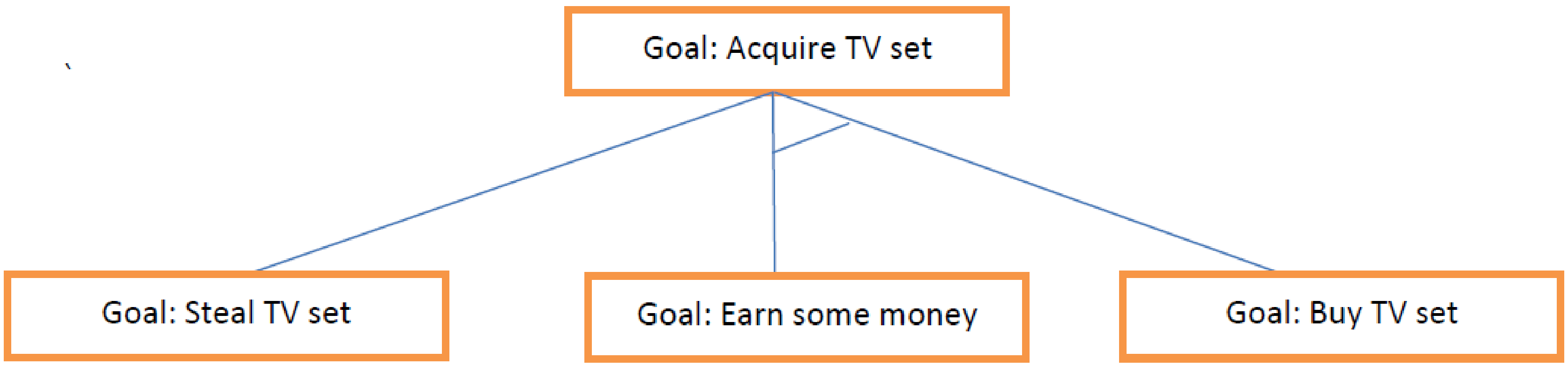
# AND/OR Graph

- An AND/OR graph is a graph which represents a problem-solving process.
- A solution graph is a subgraph of the AND/OR graph which represents a derivation for a solution of the problem.
- Therefore, solving a problem can be viewed as searching for a solution graph in an AND/OR graph. A “cost” is associated with every solution graph.
- A minimal solution graph in a solution graph with minimal cost. In this paper, an algorithm for searching for a minimal solution graph in an AND/OR graph is described.
- If the “lower bound” condition is satisfied, the algorithm is guaranteed to find a minimal solution graph when one exists.

# AND/OR Graph

- The AND-OR GRAPH (or tree) is useful for representing the solution of problems that can solved by decomposing them into a set of smaller problems, all of which must then be solved.
- This decomposition, or reduction, generates arcs that we call AND arcs. One AND arc may point to any number of successor nodes, all of which must be solved in order for the arc to point to a solution.
- Just as in an OR graph, several arcs may emerge from a single node, indicating a variety of ways in which the original problem might be solved.
- This is why the structure is called not simply an AND-graph but rather an AND-OR graph (which also happens to be an AND-OR tree)

# AND/OR Graph




A SIMPLE AND-OR GRAPH

# Algorithm

1. Let *G* be a graph with only starting node *INIT.*
2. Repeat the followings until INIT is labeled SOLVED or h(INIT) > FUTILITY
   a) *Select an unexpanded node from the most promising path from INIT (call it NODE)*
   b) Generate successors of NODE. If there are none, set h(NODE) = FUTILITY (i.e., NODE is unsolvable); otherwise for each SUCCESSOR that is not an ancestor of NODE do the following:
      i. Add SUCCESSSOR to G.
      ii. If SUCCESSOR is a terminal node, label it SOLVED and set h(SUCCESSOR) = 0.
      iii. If SUCCESSPR is not a terminal node, compute its h

# Algorithm

c) Propagate the newly discovered information up the graph by doing the following: let S be set of SOLVED nodes or nodes whose h values have been changed and need to have values propagated back to their parents. Initialize S to Node. Until S is empty repeat the followings:

i. Remove a node from S and call it CURRENT.

ii. Compute the cost of each of the arcs emerging from CURRENT. Assign minimum cost of its successors as its h.

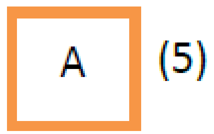
iii. Mark the best path out of CURRENT by marking the arc that had the minimum cost in step ii

iv. Mark CURRENT as SOLVED if all of the nodes connected to it through new labeled arc have been labeled SOLVED

v. If CURRENT has been labeled SOLVED or its cost was just changed, propagate its new cost back up through the graph. So add all of the ancestors of CURRENT to S.

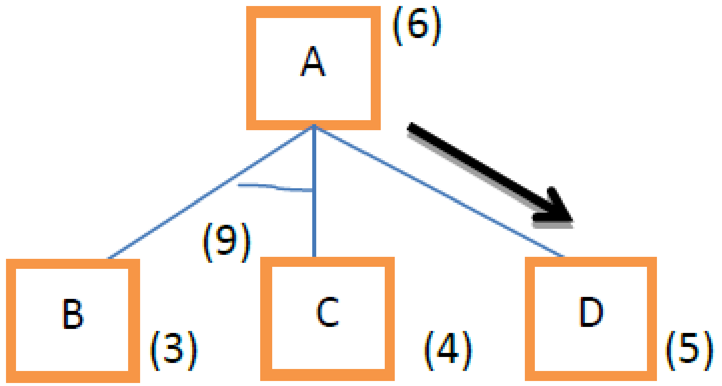
# Example Step-1

- A is the only node, it is at the end of the current best path. It is expanded, yielding nodes B, C, D.
- The arc to D is labeled as the most promising one emerging from A, since it costs 6compared to B and C, Which costs 9.



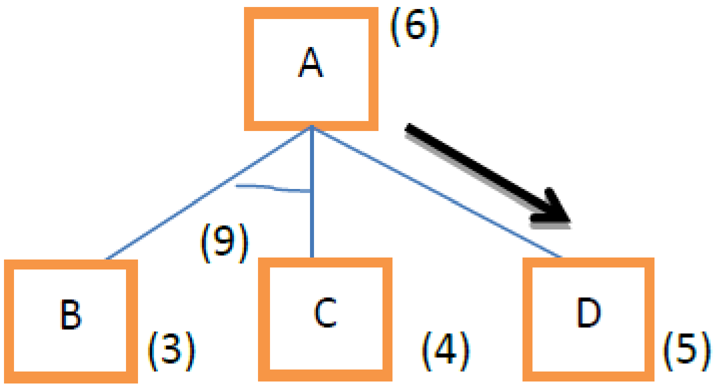
# Example Step-1

- Node B is chosen for expansion. This process produces one new arc, the AND arc to E and F, with a combined cost estimate of 10.so we update the f’ value of D to 10.
- Going back one more level, we see that this makes the AND arc B-C better than the arc to D, so it is labeled as the current best path.



# Example Step-2

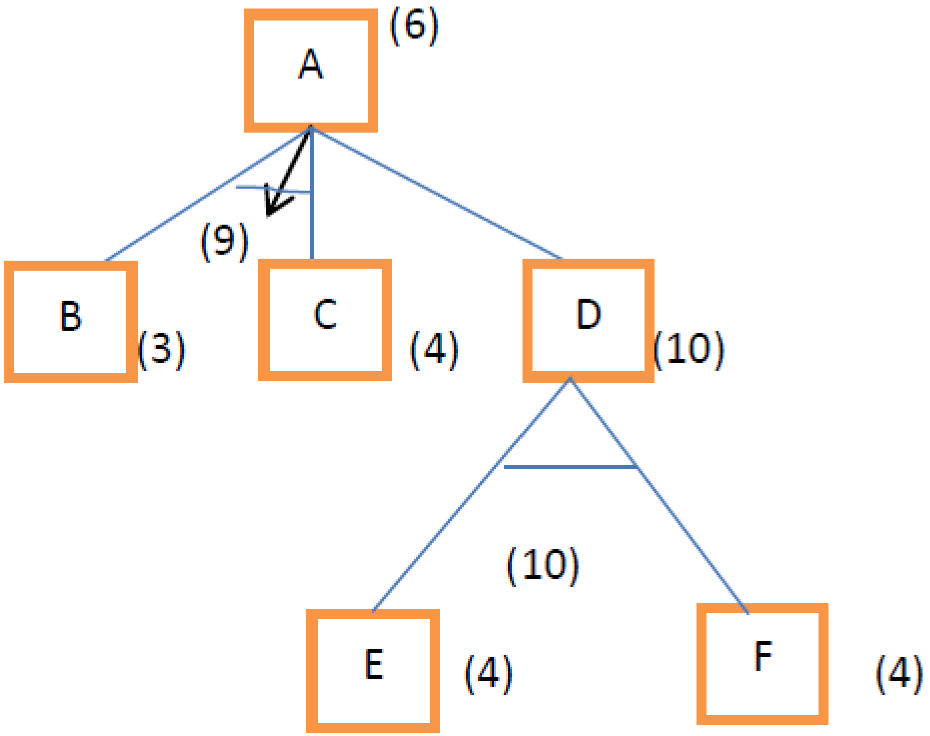
- Node B is chosen for expansion. This process produces one new arc, the AND arc to E and F, with a combined cost estimate of 10.so we update the f’ value of D to 10.
- Going back one more level, we see that this makes the AND arc B-C better than the arc to D, so it is labeled as the current best path.



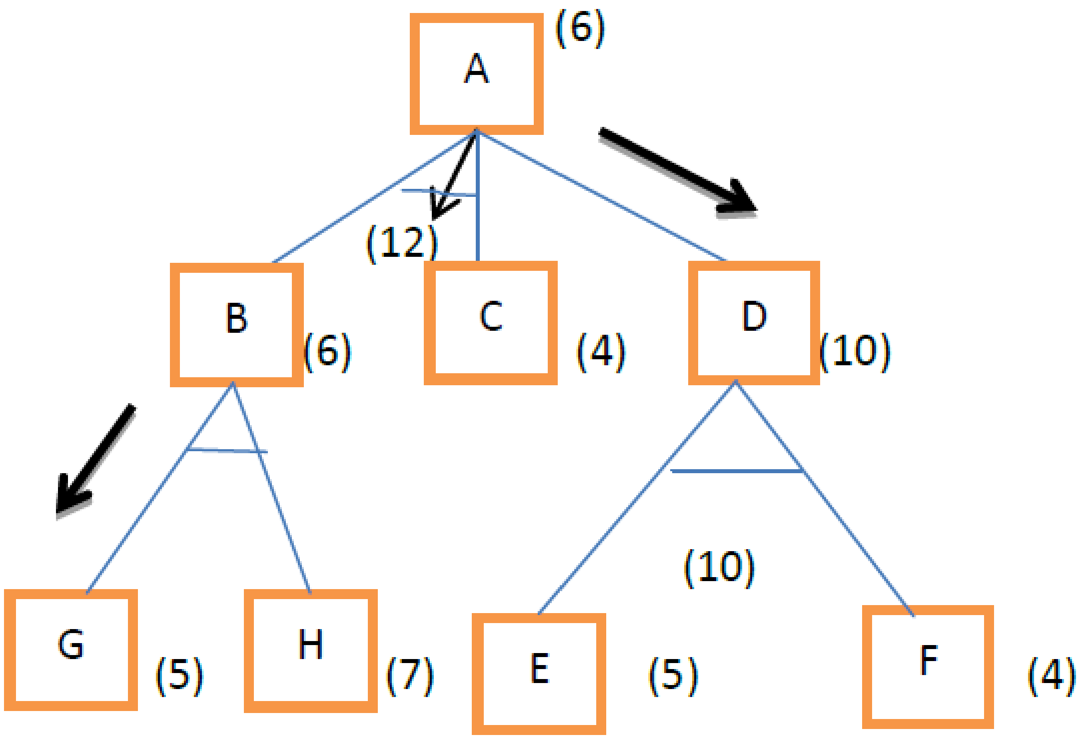
# Example Step-3

- We traverse the arc from A and discover the unexpanded nodes B and C. If we going to find a solution along this path, we will have to expand both B and C eventually, so let's choose to explore B first. This generates two new arcs, the ones to G and to H.
- Propagating their f' values backward, we update f' of B to 6(since that is the best we think we can do, which we can achieve by going through G).
- This requires updating the cost of the AND arc B-C to 12(6+4+2). After doing that, the arc to D is again the better path from A, so we record that as the current best path and either node E or node F will chosen for expansion at step 4.

# Example Step-3



# Example Step-4



# Wumpus world

- The Wumpus world is a simple world example to illustrate the worth of a knowledge-based agent and to represent knowledge representation.
- It was inspired by a video game Hunt the Wumpus by Gregory Yob in 1973.

# Wumpus world

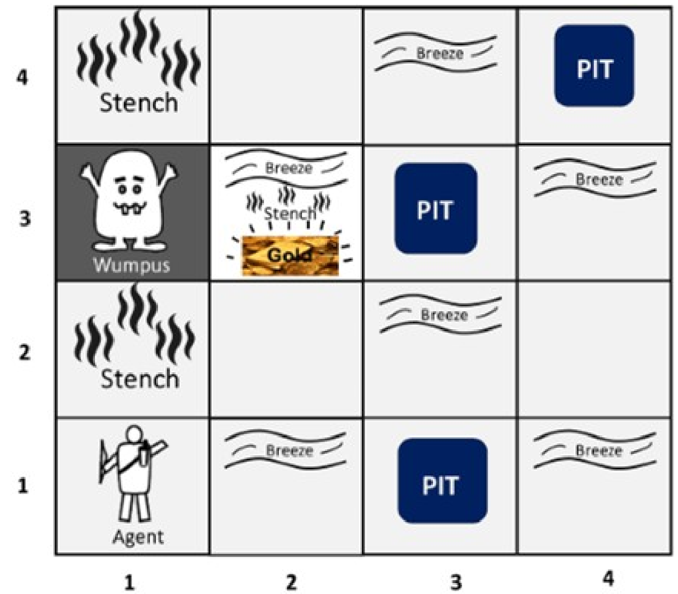
- The Wumpus world is a cave which has 4/4 rooms connected with passageways. So there are total 16 rooms which are connected with each other.
- We have a knowledge-based agent who will go forward in this world.
- The cave has a room with a beast which is called Wumpus, who eats anyone who enters the room.
- The Wumpus can be shot by the agent, but the agent has a single arrow.

# Wumpus world

- In the Wumpus world, there are some Pits rooms which are bottomless, and if agent falls in Pits, then he will be stuck there forever.
- The exciting thing with this cave is that in one room there is a possibility of finding a heap of gold. So the agent goal is to find the gold and climb out the cave without fallen into Pits or eaten by Wumpus.
- The agent will get a reward if he comes out with gold, and he will get a penalty if eaten by Wumpus or falls in the pit.

# Wumpus world

- Following is a sample diagram for representing the Wumpus world.
- It is showing some rooms with Pits, one room with Wumpus and one agent at (1, 1) square location of the world.



# Wumpus world

- There are also some components which can help the agent to navigate the cave. These components are given as follows:
  - The rooms adjacent to the Wumpus room are smelly, so that it would have some stench.
  - The room adjacent to PITs has a breeze, so if the agent reaches near to PIT, then he will perceive the breeze.
  - There will be glitter in the room if and only if the room has gold.
  - The Wumpus can be killed by the agent if the agent is facing to it, and Wumpus will emit a horrible scream which can be heard anywhere in the cave.

# PEAS description of Wumpus world

- To explain the Wumpus world we have given PEAS description as below:
- Performance measure:
  - +1000 reward points if the agent comes out of the cave with the gold.
  - -1000 points penalty for being eaten by the Wumpus or falling into the pit.
  - -1 for each action, and -10 for using an arrow.
  - The game ends if either agent dies or came out of the cave.

# PEAS description of Wumpus world

- Environment:
  - A 4*4 grid of rooms.
  - The agent initially in room square [1, 1], facing toward the right.
  - Location of Wumpus and gold are chosen randomly except the first square [1,1].
  - Each square of the cave can be a pit with probability 0.2 except the first square.

# PEAS description of Wumpus world

- Actuators:
  - Left turn,
  - Right turn
  - Move forward
  - Grab
  - Release
  - Shoot.

# PEAS description of Wumpus world

- Sensors:
  - The agent will perceive the stench if he is in the room adjacent to the Wumpus. (Not diagonally).
  - The agent will perceive breeze if he is in the room directly adjacent to the Pit.
  - The agent will perceive the glitter in the room where the gold is present.
  - The agent will perceive the bump if he walks into a wall.
  - When the Wumpus is shot, it emits a horrible scream which can be perceived anywhere in the cave.
  - These percepts can be represented as five element list, in which we will have different indicators for each sensor.
  - Example if agent perceives stench, breeze, but no glitter, no bump, and no scream then it can be represented as: [Stench, Breeze, None, None, None].

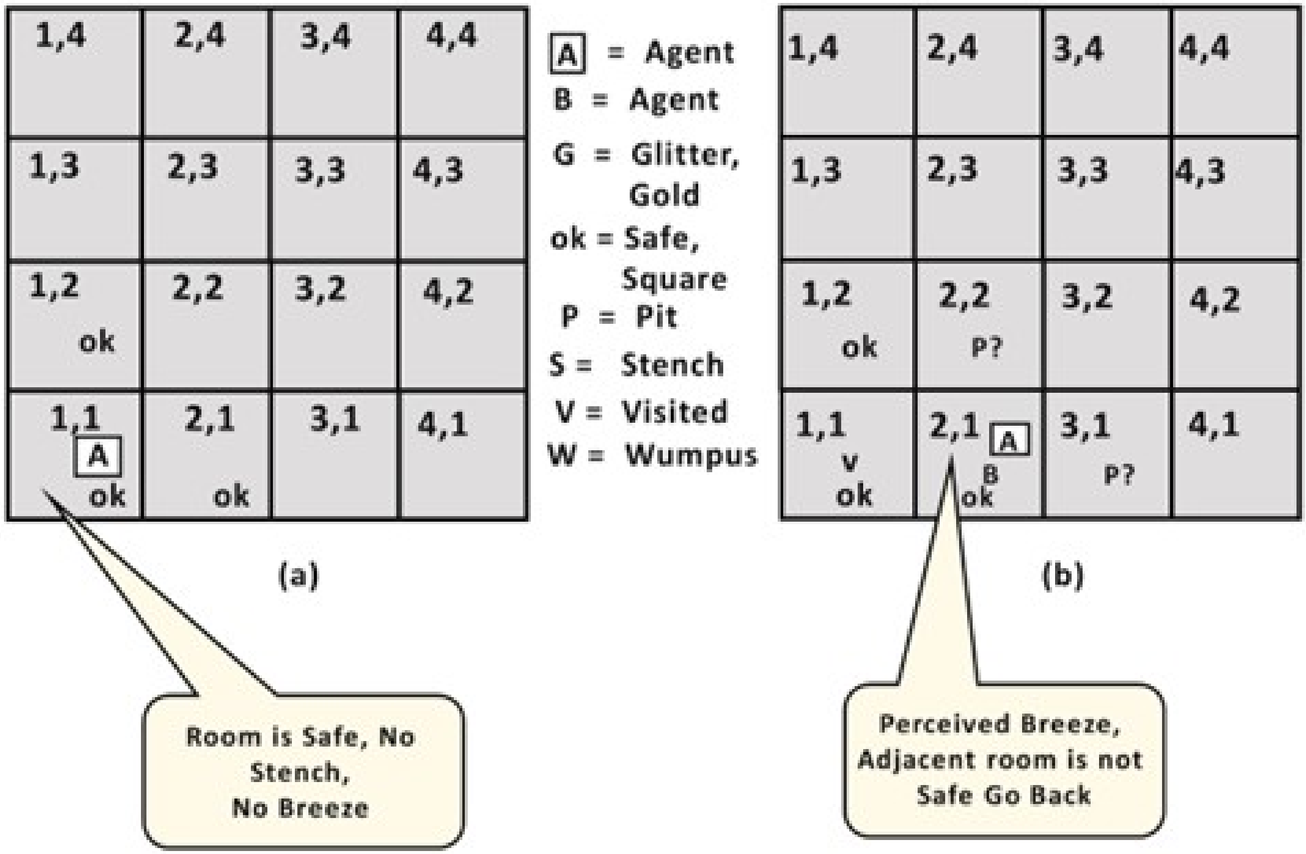
# The Wumpus world Properties

- Partially observable: The Wumpus world is partially observable because the agent can only perceive the close environment such as an adjacent room.
- Deterministic: It is deterministic, as the result and outcome of the world are already known.
- Sequential: The order is important, so it is sequential.
- Static: It is static as Wumpus and Pits are not moving.
- Discrete: The environment is discrete.
- One agent: The environment is a single agent as we have one agent only and Wumpus is not considered as an agent.

# Exploring the Wumpus world

- Now we will explore the Wumpus world and will determine how the agent will find its goal by applying logical reasoning.
- Agent's First step:
  - Initially, the agent is in the first room or on the square [1,1], and we already know that this room is safe for the agent, so to represent on the below diagram (a) that room is safe we will add symbol OK. Symbol A is used to represent agent, symbol B for the breeze, G for Glitter or gold, V for the visited room, P for pits, W for Wumpus.
  - At Room [1,1] agent does not feel any breeze or any Stench which means the adjacent squares are also OK.

# Exploring the Wumpus world



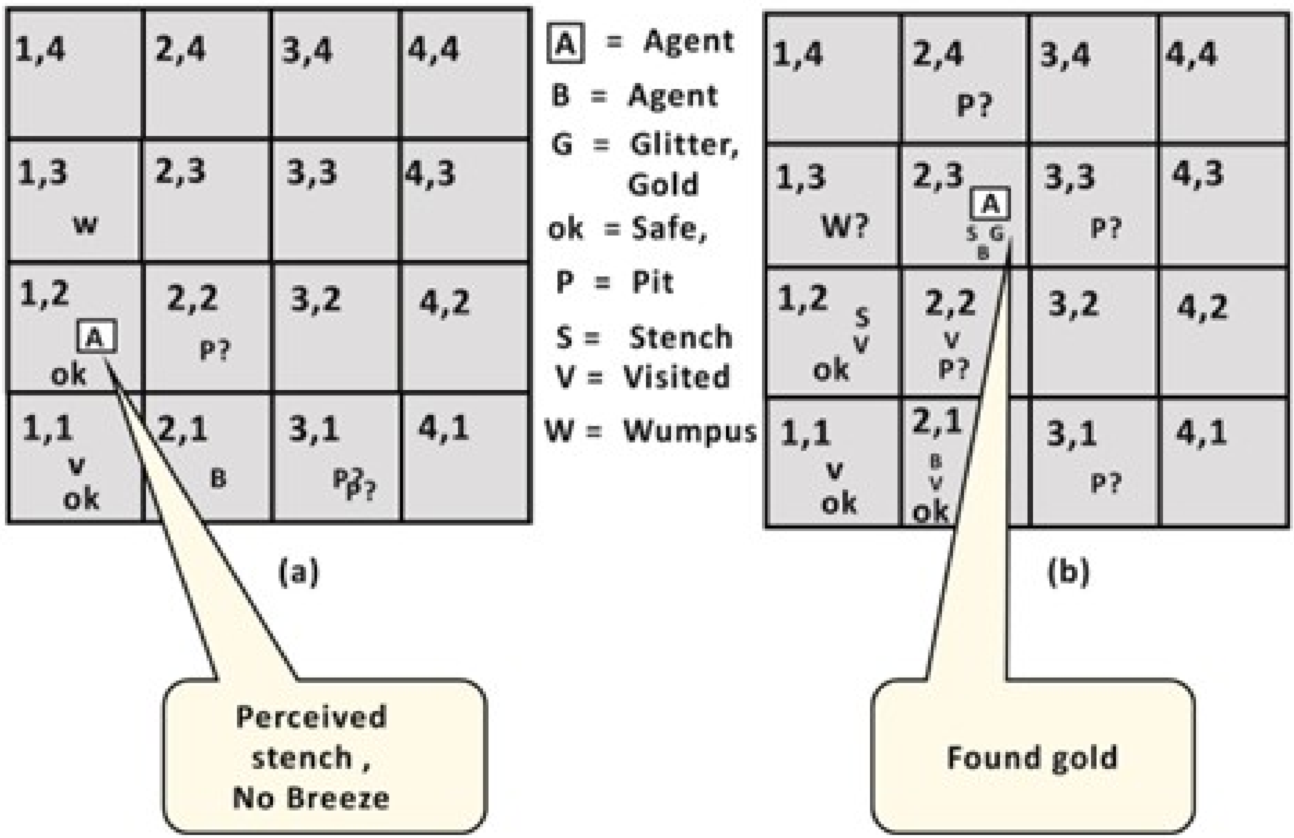
# Exploring the Wumpus world

- Agent's second Step:
  - Now agent needs to move forward, so it will either move to [1, 2], or [2,1]. Let's suppose agent moves to the room [2, 1], at this room agent perceives some breeze which means Pit is around this room. The pit can be in [3, 1], or [2,2], so we will add symbol P? to say that, is this Pit room?
  - Now agent will stop and think and will not make any harmful move. The agent will go back to the [1, 1] room. The room [1,1], and [2,1] are visited by the agent, so we will use symbol V to represent the visited squares.

# Exploring the Wumpus world

- Agent's third step:
  - At the third step, now agent will move to the room [1,2] which is OK. In the room [1,2] agent perceives a stench which means there must be a Wumpus nearby.
  - But Wumpus cannot be in the room [1,1] as by rules of the game, and also not in [2,2] (Agent had not detected any stench when he was at [2,1]).
  - Therefore agent infers that Wumpus is in the room [1,3], and in current state, there is no breeze which means in [2,2] there is no Pit and no Wumpus. So it is safe, and we will mark it OK, and the agent moves further in [2,2].

# Exploring the Wumpus world



# Exploring the Wumpus world

- Agent's fourth step:
  - At room [2,2], here no stench and no breezes present so let's suppose agent decides to move to [2,3].
  - At room [2,3] agent perceives glitter, so it should grab the gold and climb out of the cave.

# Thank you



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