Single agent or multiple agents

- Many domains are characterized by multiple agents rather than a single agent.
- Game theory studies what agents should do in a multi-agent setting. A game is an abstraction of agents interacting.
- Agents can be cooperative, competitive or somewhere in between.
- Agents that reason and act autonomoulsly can't be modeled as nature.

Multi-agent framework

- Each agent can have its own utility.
- Agents select actions autonomously.
- Agents can have different information.
- The outcome can depend on the actions of all of the agents.
- Each agent's value depends on the outcome.

Normal Form of a Game

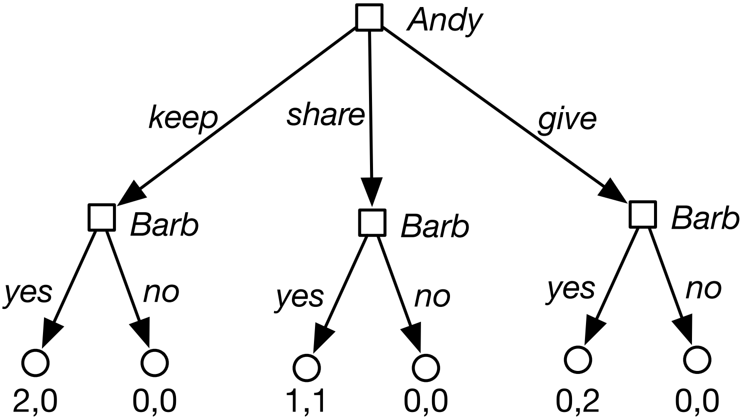
The strategic form of a game or normal-form game:

- a finite set I of agents, $\{1, \dots, n\}$.
- a set of actions A_i for each agent $i \in I$.
  An action profile σ is a tuple $\langle a_1, \dots, a_n \rangle$, means agent i carries out a_i.
- a utility function $utility(\sigma, i)$ for action profile σ and agent $i \in I$, gives the expected utility for agent i when all agents follow action profile σ.

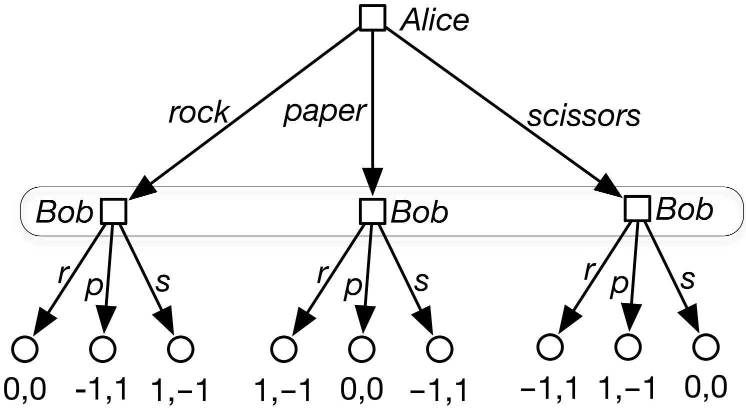
Rock-Paper-Scissors

		Bob		
		rock	*paper*	*scissors*
	rock	$0, 0$	$-1, 1$	$1, -1$
Alice	*paper*	$1, -1$	$0, 0$	$-1, 1$
	scissors	$-1, 1$	$1, -1$	0,0

Extensive Form of a Game

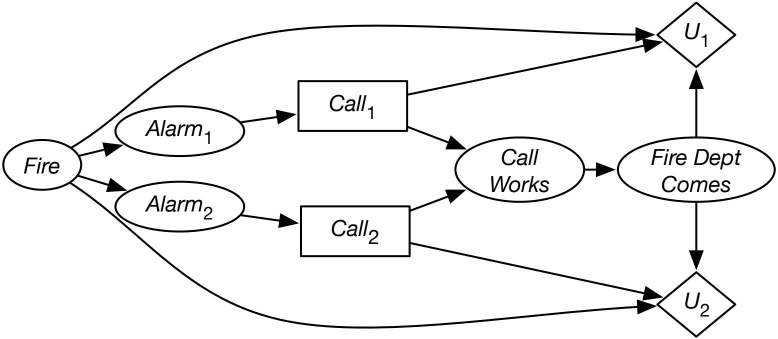


Extensive Form of an imperfect-information Game



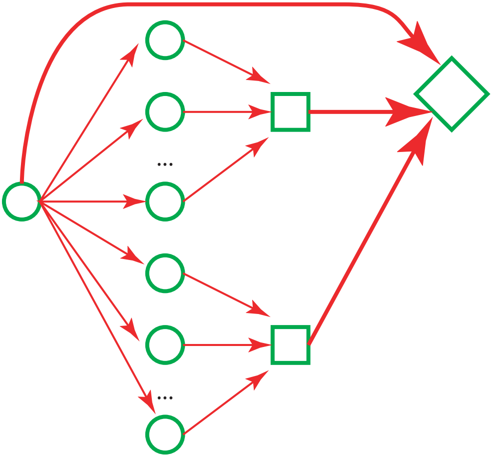
Bob cannot distinguish the nodes in an information set.

Multiagent Decision Networks



Value node for each agent.
Each decision node is owned by an agent.
The parents of each decision node specify what that agent will observe when making the decision

Multiple Agents, shared value



Complexity of Multi-agent decision theory

- It can be exponentially harder to find optimal multi-agent policy even with a shared values.
- Why? Because dynamic programming doesn't work:
  - If a decision node has n binary parents, dynamic programming lets us solve 2^n decision problems.
  - This is much better than d^{2^n} policies (where d is the number of decision alternatives).
- Multiple agents with shared values is equivalent to having a single forgetful agent.