

The Implications of case-based reasoning in strategic contexts

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PRESENTATION OUTLINE

- **Background and motivation**
- **Case-based reasoning**
- **A specific model**
- **A more general model**
- **Conclusions**



BACKGROUND AND MOTIVATION

Limitations of mainstream game theory:

- Instrumental rationality
- Hypotheses about players' assumptions on:
 - Other player's cognitive capabilities
 - Other player's beliefs
- Many possible outcomes
- Dynamics ignored
- No adaptation (pre-planned strategies)



BACKGROUND AND MOTIVATION

New approaches:

- **Cognitively more (or equally) plausible decision making algorithms, e.g.:**
 - Reinforcement learning (Erev et al. 1999; Bendor et al. 2001; Macy and Flache 2002)
 - Belief learning (Fudenberg and Levine 1998)
 - EWA model (Camerer 2003)
 - Case-based reasoning (Izquierdo et al. 2004)
- **Dynamics, in addition to long-term behaviour**



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CASE-BASED REASONING

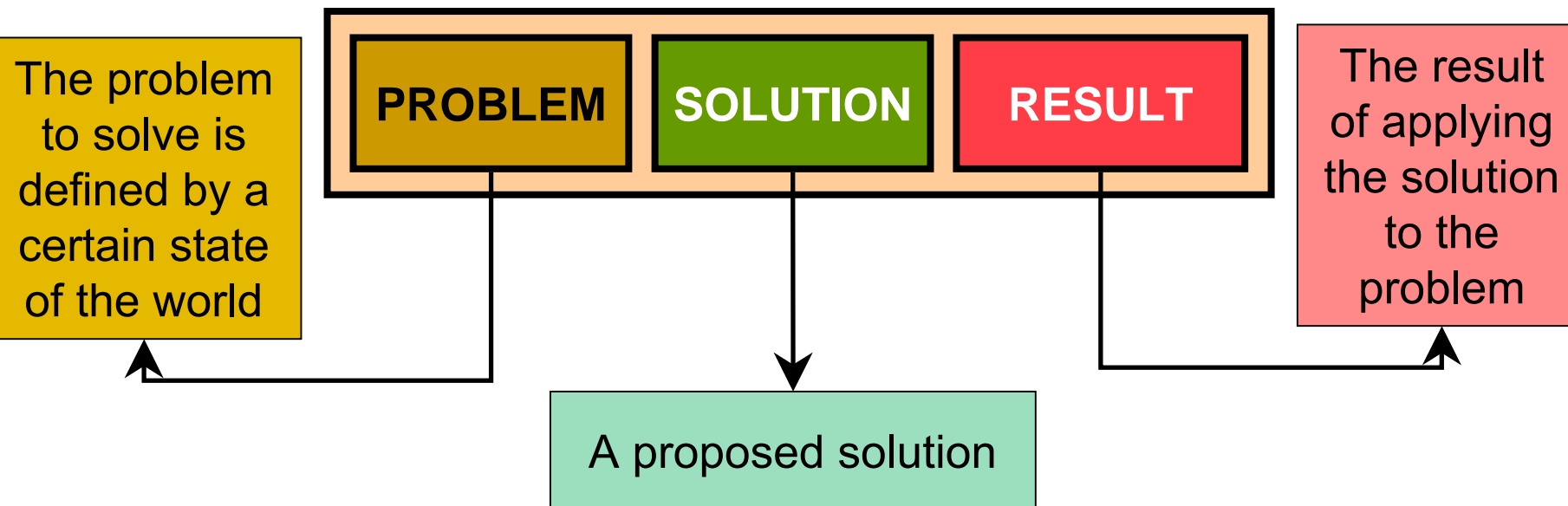
Basically, case-based reasoning consists in solving a problem by remembering a previous similar situation and by reusing information and knowledge of that situation.

A. Aamodt & E. Plaza (1994)






CASE-BASED REASONING

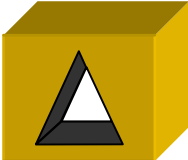


A **case** is a contextualised piece of knowledge representing an experience



What is a case?



PROBLEM	SOLUTION	RESULT
		

PROBLEM	SOLUTION	RESULT
		



Why is this interesting?

Reasoning by rules (strategies)

vs.

Reasoning by cases (outcomes)

		Player 2	
		Cooperate	Defect
Player 1	Cooperate	3, 3	1, 4
	Defect	4, 1	2, 2



Why is this interesting?

Strategies:

- Rational players choose strictly dominant strategies

Outcomes:

- Rational outcomes must be Pareto optimal

		Player 2	
		Cooperate	Defect
Player 1	Cooperate	3, 3	1, 4
	Defect	4, 1	2, 2

Rational strategies lead to **outcomes that are not rational**

Rational outcomes are generated by **strategies that are not rational**

















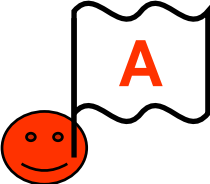










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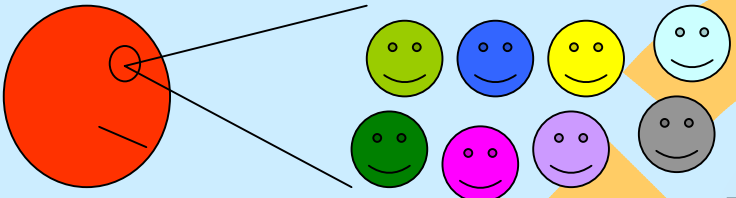
What is a case for an agent i : 😊 ?

STATE OF THE WORLD	DECISION	PAYOFF															
<p>Decisions made by everyone in the preceding m_i time-steps</p>	<p>😊's decision at time t:</p>	<p>😊's payoff at time t:</p>															
<table border="1" data-bbox="69 814 846 1153"><thead><tr><th>$t-m_i$</th><th>...</th><th>$t-3$</th><th>$t-2$</th><th>$t-1$</th></tr></thead><tbody><tr><td></td><td>...</td><td></td><td></td><td></td></tr><tr><td></td><td>...</td><td></td><td></td><td></td></tr></tbody></table>	$t-m_i$...	$t-3$	$t-2$	$t-1$		...					...					<p>10</p>
$t-m_i$...	$t-3$	$t-2$	$t-1$													
	...																
	...																



Examine current situation

State of World



Remember previous similar situations

State of World	A	5
State of World	B	3
State of World	C	6

(Most recent for each action)

Agents' Cycle

St World	B	3
...		

St World C 4

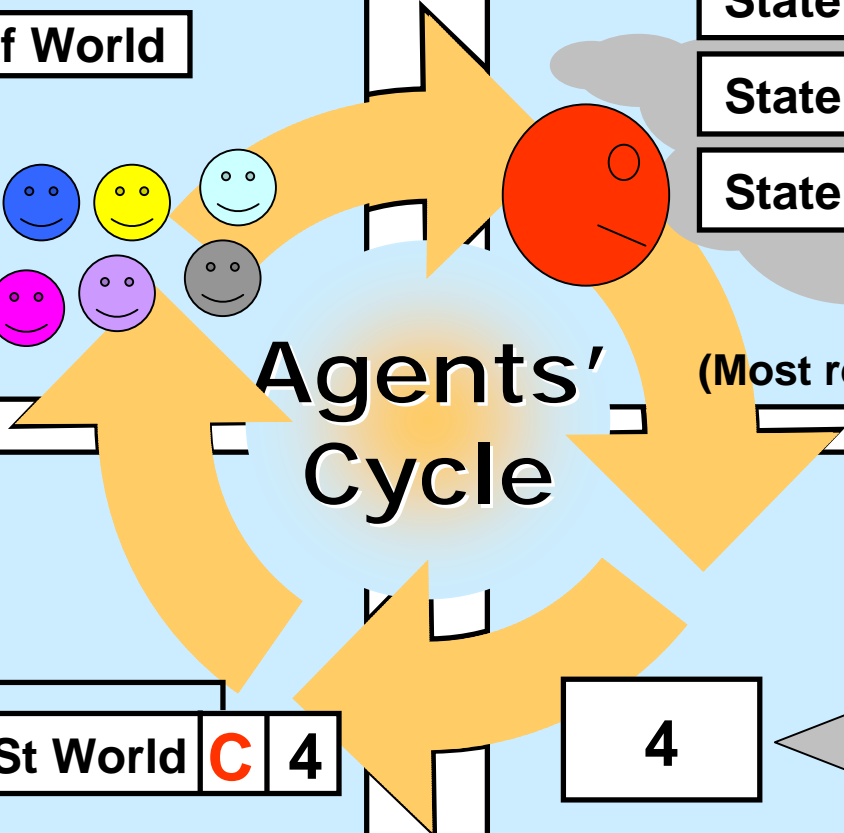
Update memory

4

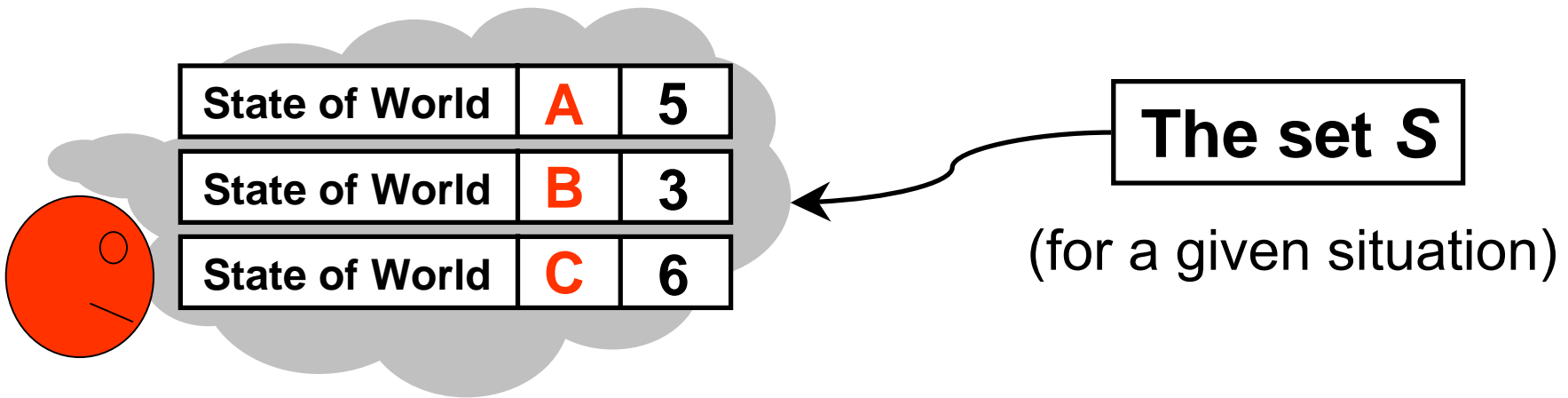
C

(Choose highest payoff OR experiment)

Decide and apply solution



The set C of most recent similar cases

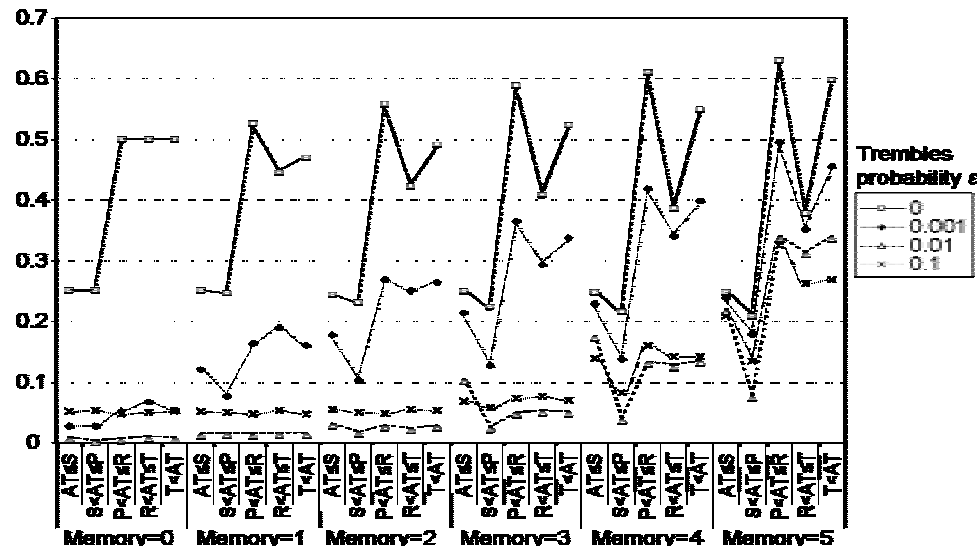


- S is empty **Choose at random**
- S is non-empty, but not complete: Identify highest payoff H
 - If $H \geq \textit{Aspiration}$ **Choose Action(H)**
 - If $H < \textit{Aspiration}$ **Explore a new action**
- S is complete (all actions represented) **Choose Action(H)**



Transient dynamics (specific model)

- Dynamics very dependent on:
 - Players' memory
 - Players' Aspirations
 - How often, and in which way, players experiment



Long-term dynamics (specific model)

Stochastically stable outcomes:

**Outcomes that persist in the long-term...
... when the probability of experimentation
(or trembles) tend to zero.**

Whether an outcome is stochastically stable or not is independent of:

- Players' memory
- Players' Aspirations
- How often, and in which way, players experiment



Long-term dynamics (specific model)

		Player 2	
		Cooperate	Defect
Player 1	Cooperate	3, 3	1, 4
	Defect	4, 1	2, 2

The table is a 2x2 matrix representing a game between Player 1 and Player 2. The rows represent Player 1's strategies (Cooperate, Defect) and the columns represent Player 2's strategies (Cooperate, Defect). The payoffs are listed as (Player 1, Player 2). The cell for (Player 1 Defect, Player 2 Defect) with payoffs (2, 2) is circled in red.

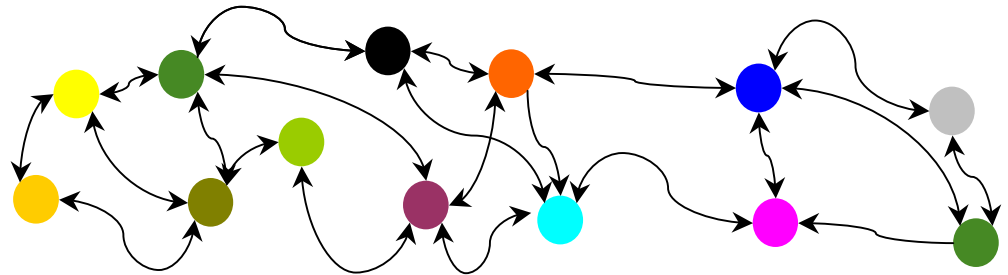


Stochastically stable outcomes

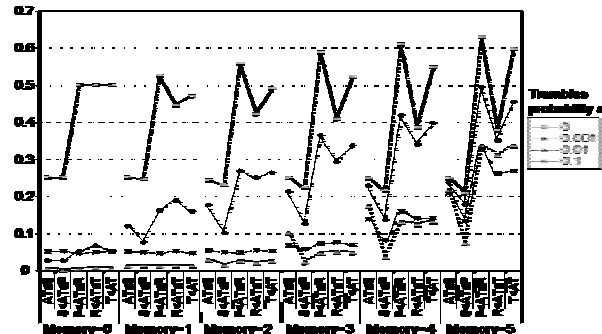
1. Calculate limits

$$\lim_{\varepsilon \rightarrow 0} \begin{pmatrix} \varepsilon & 0 & 0 & 1-\varepsilon \\ 0 & 1-\varepsilon & \varepsilon & 0 \\ 0 & 0 & \varepsilon & 1-\varepsilon \\ 1-\varepsilon & \varepsilon & 0 & 0 \end{pmatrix}$$

2. Solve a series of shortest path problems in a graph



3. Simulations

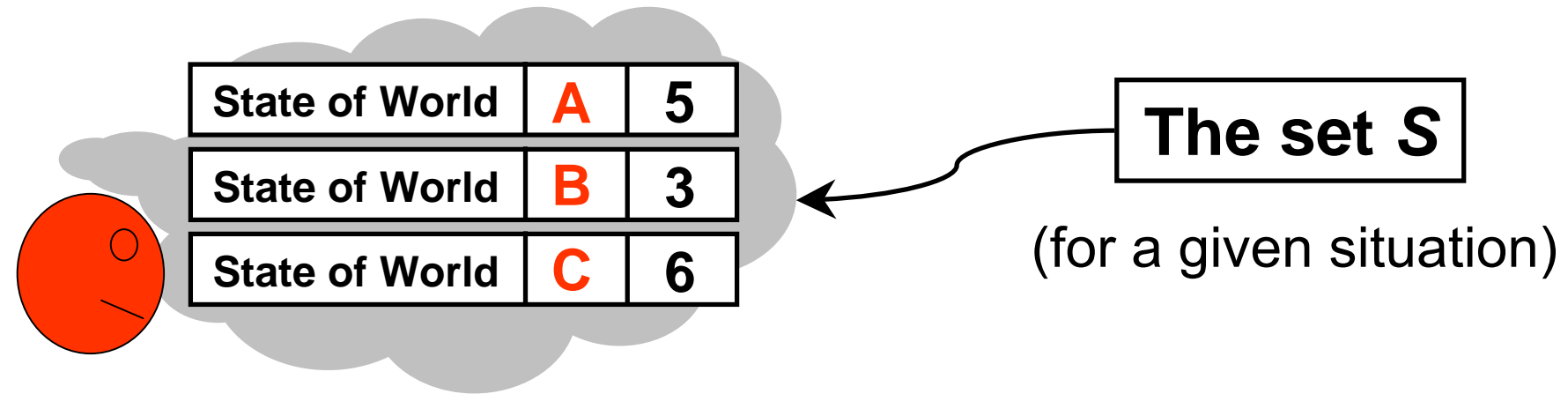


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A more general model: The set S of most recent similar cases

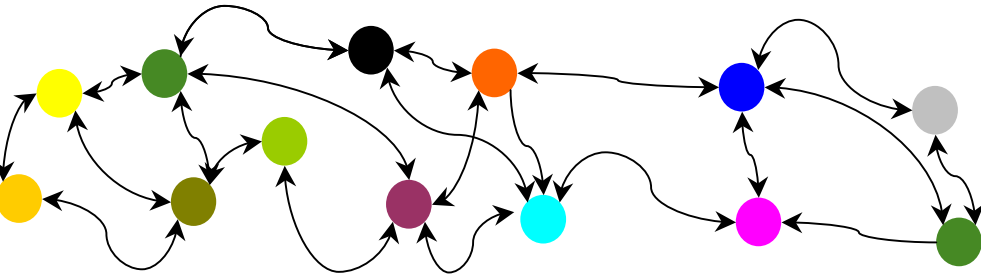


- Finite number of different types of situation
- Experimentation (or trembles)
- S is complete (all actions represented)

Choose Action(H)



Stochastically stable outcomes



1. Calculate limits
2. Solve a series of shortest path problems in a graph

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Stochastically stable outcomes

- Always individually rational
- Not a clear relationship with Nash equilibria
- Not a clear relationship with Pareto optima
- Related to the concept of Protected Nash
 - Giving the deviator a higher payoff (Nash)
 - Giving a non-deviator a lower payoff (Protection)
- e.g., in 2×2 games with a protected strict Nash equilibrium, the only stochastically stable state is such an equilibrium



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CONCLUSIONS

- **New (at least equally plausible) assumptions within the framework of game theory give rise to new solution concepts.**
- **These new solution concepts are not necessarily related to well-known concepts such as Nash equilibrium.**



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PD: Average cooperation rate calculated over time-steps 1001–1100

