

Computer Poker Research at The University of Alberta



Richard Gibson

Computing Science Honours Seminar
February 25, 2013

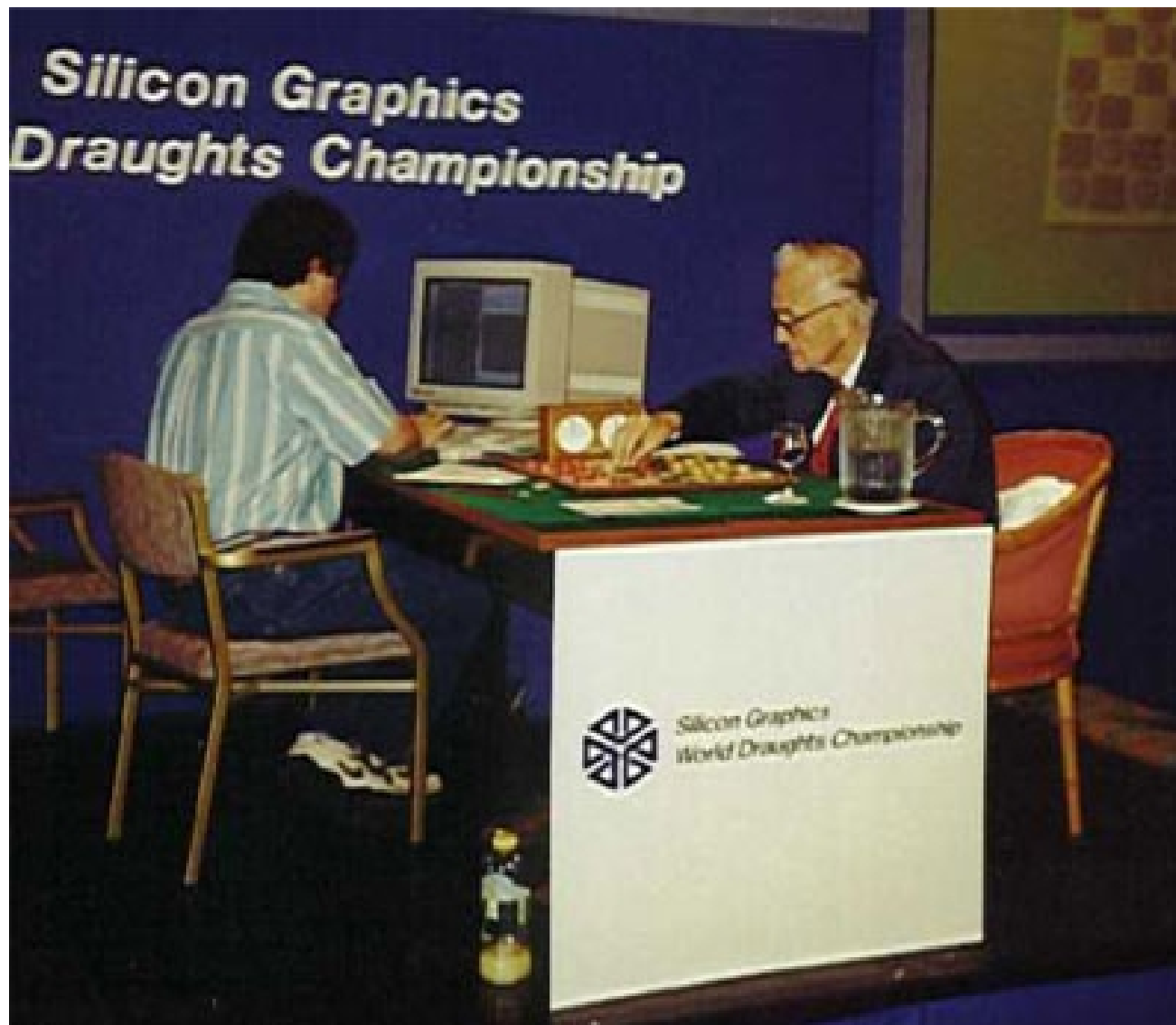


*Making
IT
happen*

Computing Science

Games have been used to showcase advances in artificial intelligence...

Checkers



Source: spectrum.ieee.org

Chess



Source: robertamsterdam.com

VS



Source: Wikipedia

Goal: Build a computer poker program capable of defeating the world's best human players!



Overview

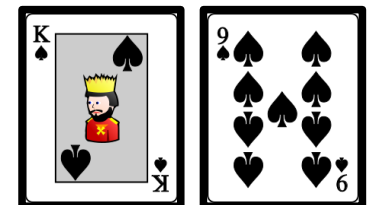
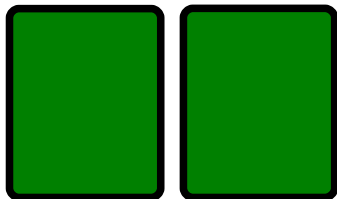
- Texas Hold'em
 - Why is poker research interesting?
 - Computer Poker Research Group
- Creating Polaris, a poker-playing program
 - Nash equilibrium
 - Abstraction
- Polaris in Action
 - Annual Computer Poker Competition (Programs vs. Programs)
 - Man vs. Machine Competitions
- Future Directions

Overview

- **Texas Hold'em**
 - **Why is poker research interesting?**
 - **Computer Poker Research Group**
- **Creating Polaris, a poker-playing program**
 - Nash equilibrium
 - Abstraction
- **Polaris in Action**
 - Annual Computer Poker Competition (Programs vs. Programs)
 - Man vs. Machine Competitions
- **Future Directions**

Texas Hold'em Poker

Source: ebaumsworld.com

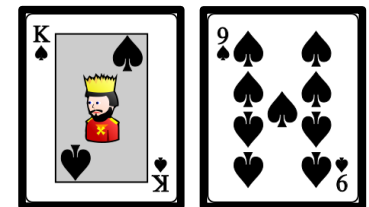
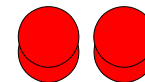
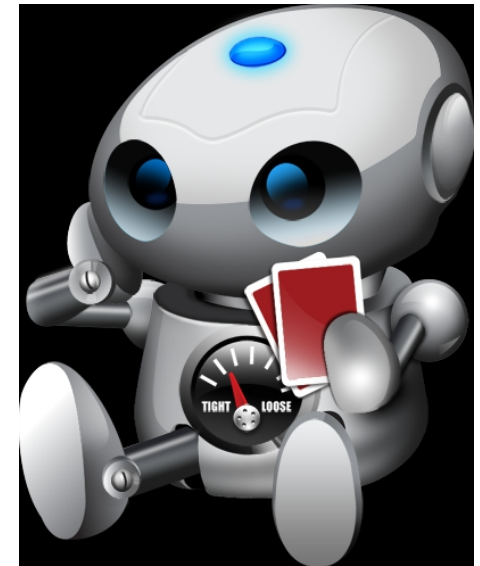
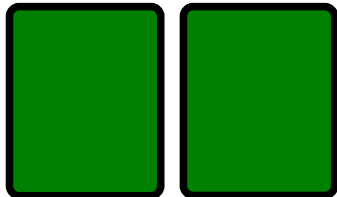


Source: Wikipedia

Dealer

Texas Hold'em Poker

Source: ebaumsworld.com

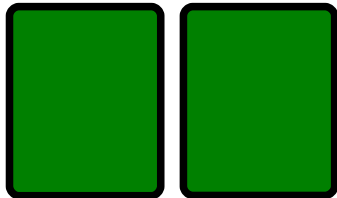
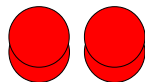


Raise!

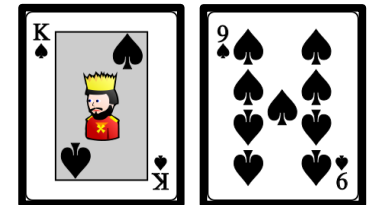
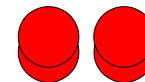
Dealer

Texas Hold'em Poker

Source: ebaumsworld.com



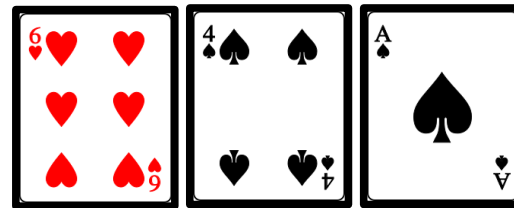
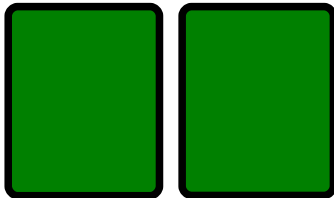
Call.



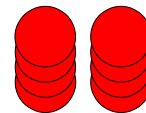
Dealer

Texas Hold'em Poker

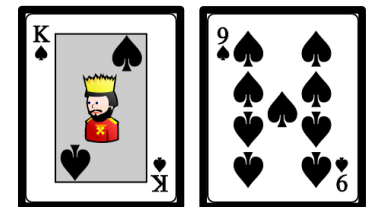
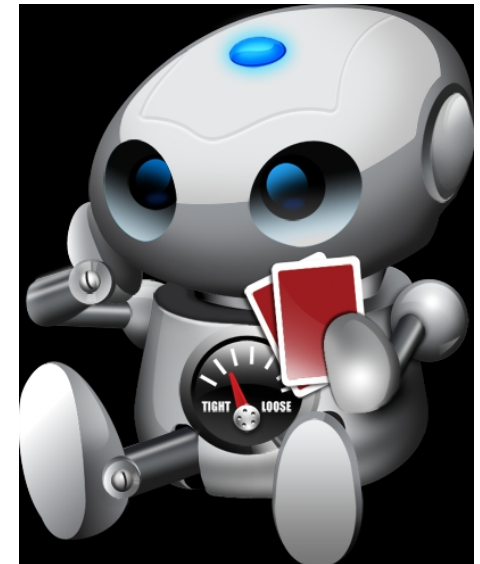
Source: ebaumsworld.com



Flop



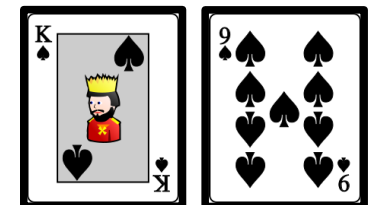
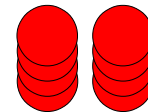
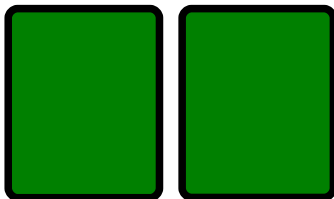
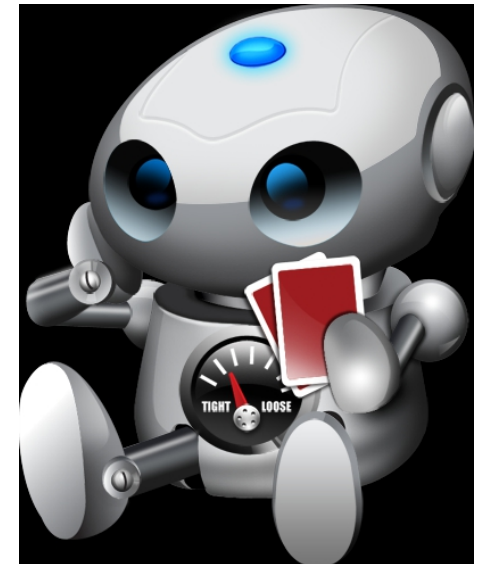
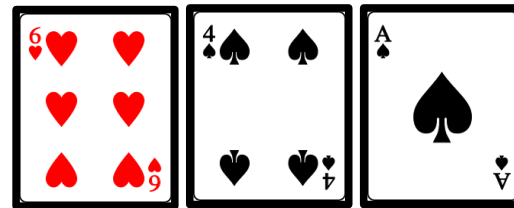
Pot



Dealer

Texas Hold'em Poker

Source: ebaumsworld.com

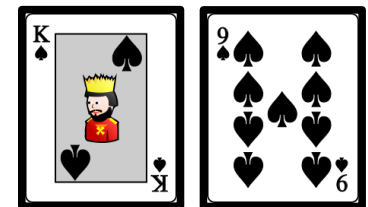
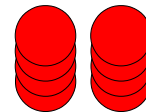
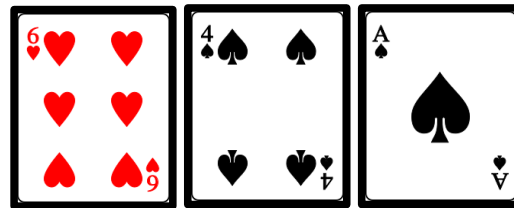
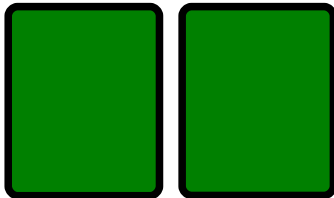


Check.

Dealer

Texas Hold'em Poker

Source: ebaumsworld.com

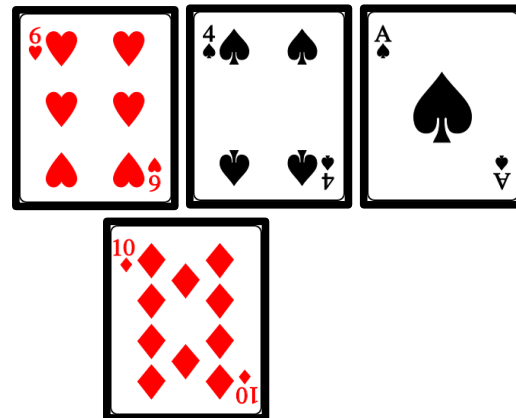
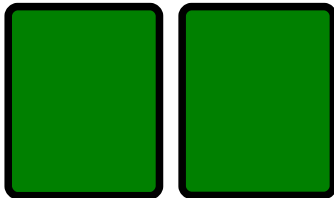


Check.

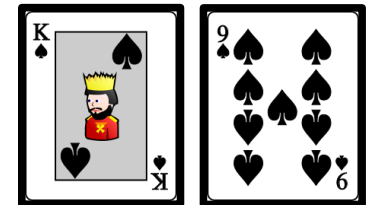
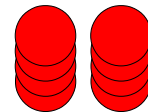
Dealer

Texas Hold'em Poker

Source: ebaumsworld.com



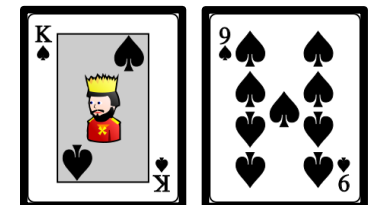
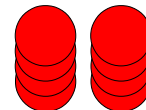
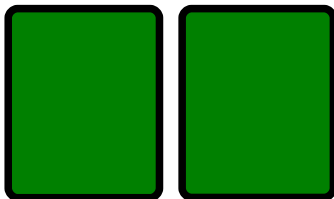
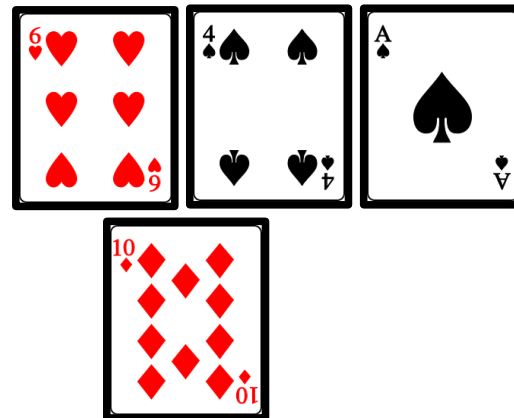
Turn



Dealer

Texas Hold'em Poker

Source: ebaumsworld.com

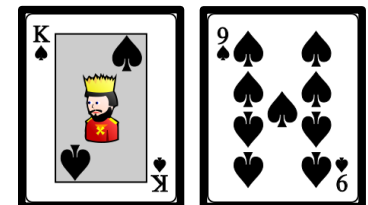
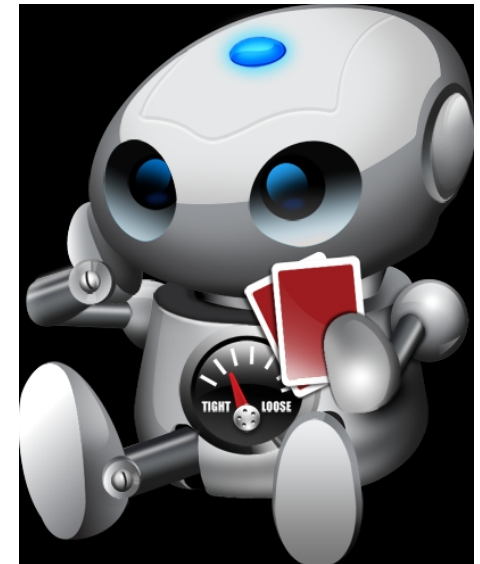
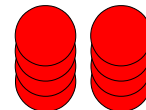
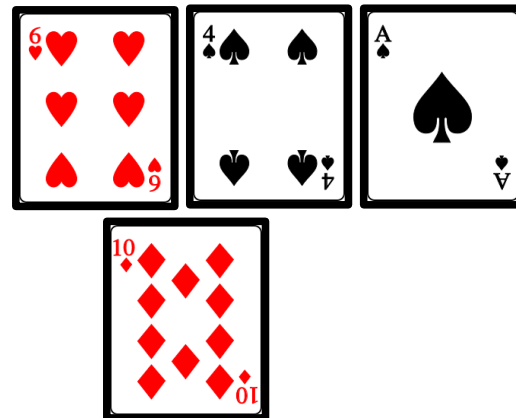


Bet!

Dealer

Texas Hold'em Poker

Source: ebaumsworld.com

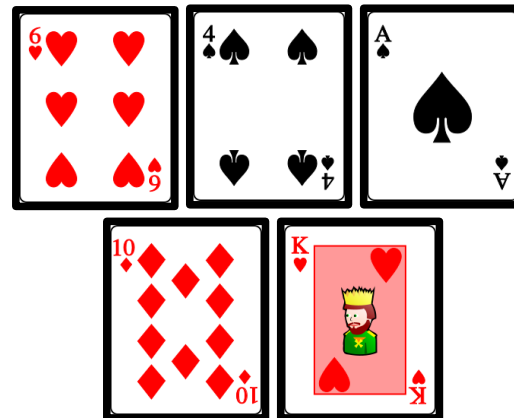
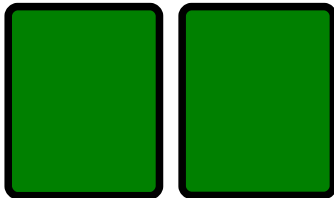


Call.

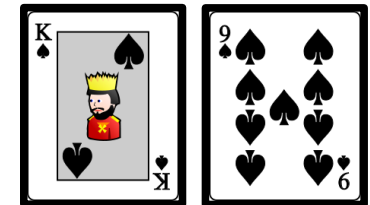
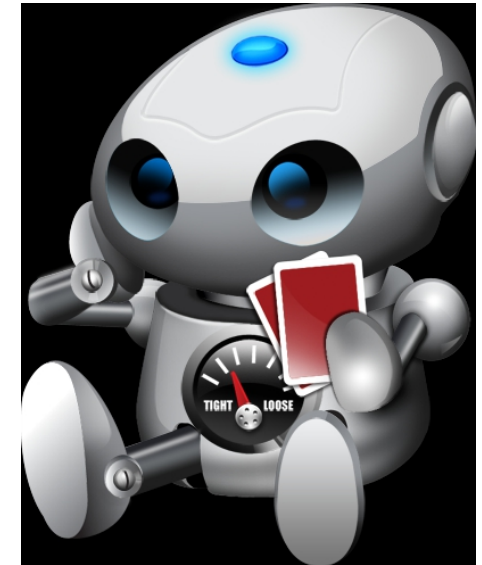
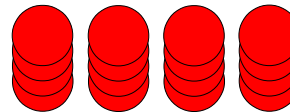
Dealer

Texas Hold'em Poker

Source: ebaumsworld.com



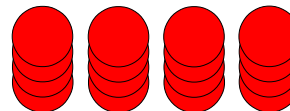
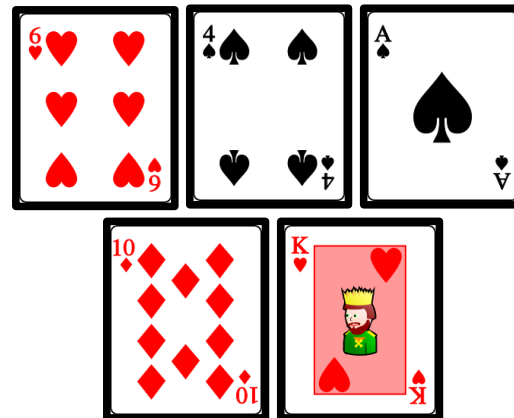
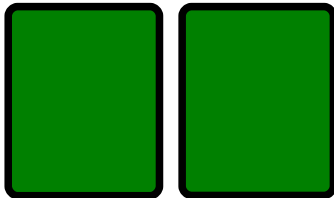
River



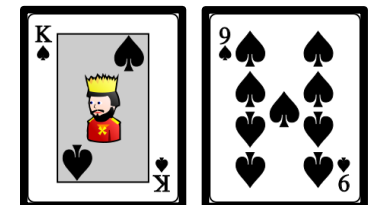
Dealer

Texas Hold'em Poker

Source: ebaumsworld.com



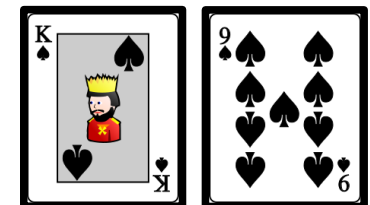
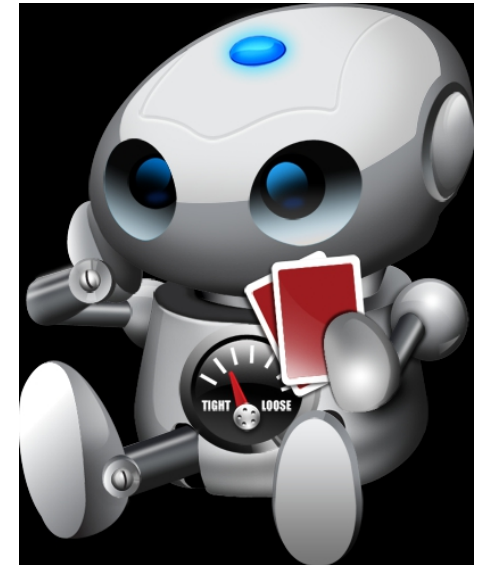
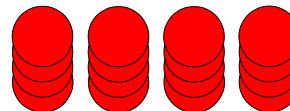
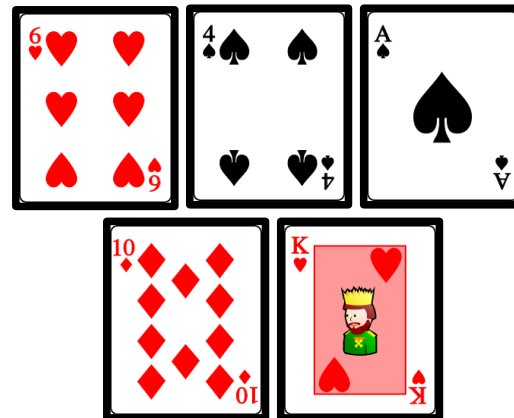
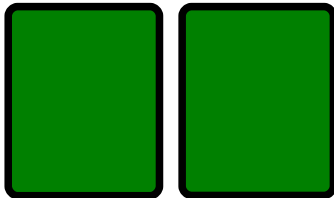
Check.



Dealer

Texas Hold'em Poker

Source: ebaumsworld.com

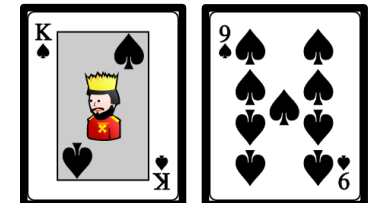
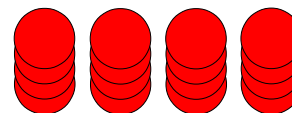
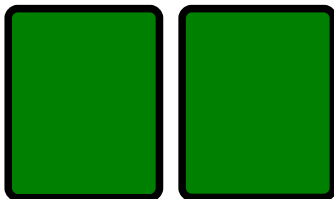
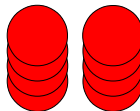
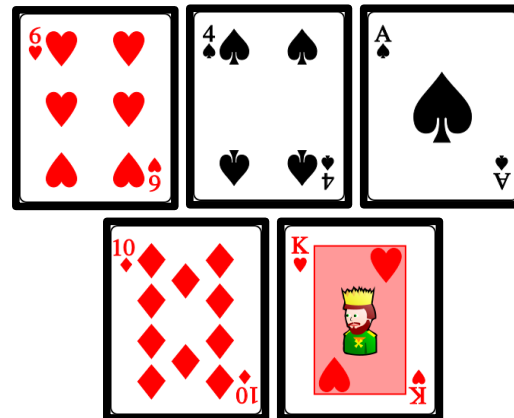


Bet!

Dealer

Texas Hold'em Poker

Source: ebaumsworld.com

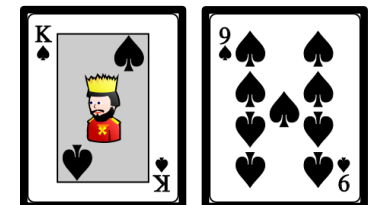
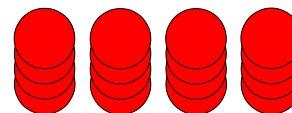
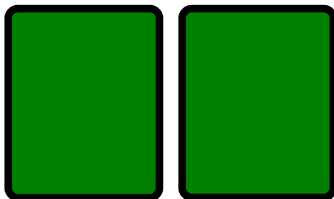
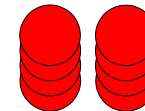
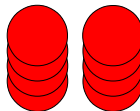
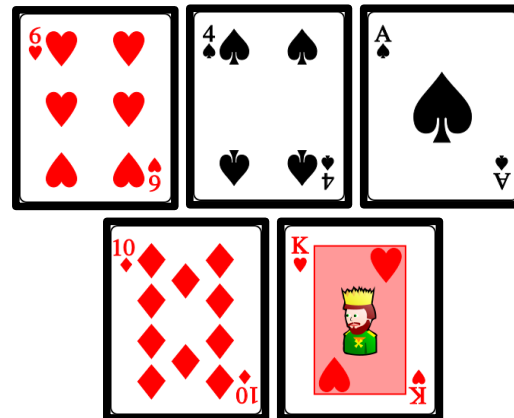


Raise!

Dealer

Texas Hold'em Poker

Source: ebaumsworld.com

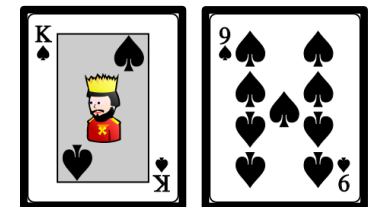
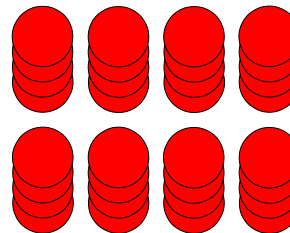
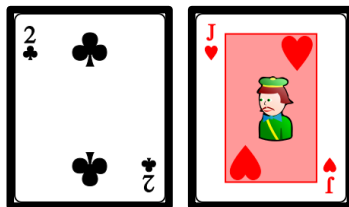
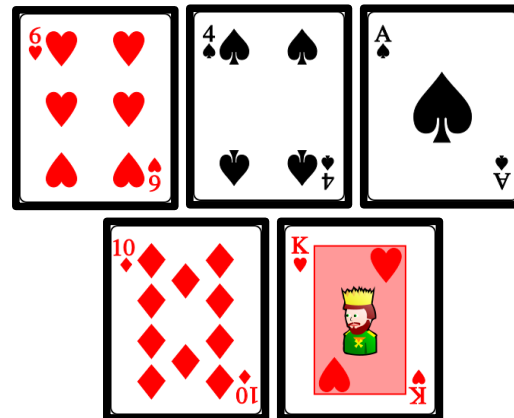


Call.

Dealer

Texas Hold'em Poker

Source: ebaumsworld.com

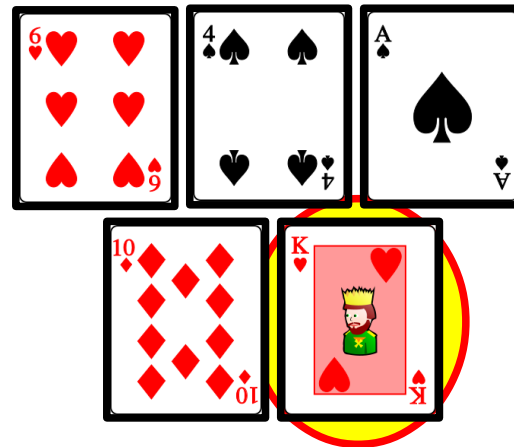
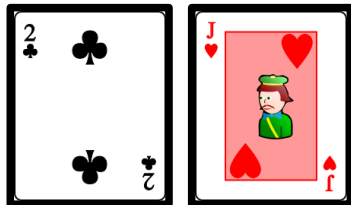


Dealer

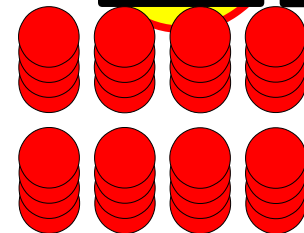
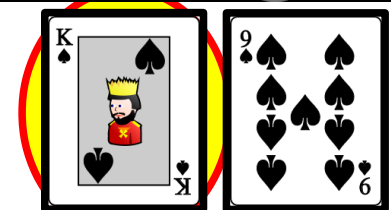
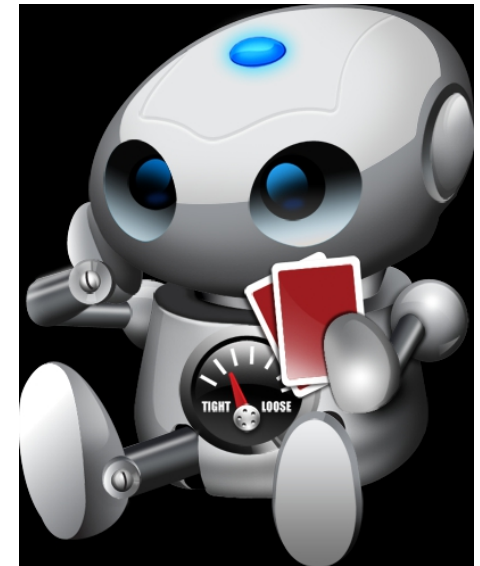
Texas Hold'em Poker

Loser.

Source: ebaumsworld.com



Winner!



Dealer

Why is Poker Interesting?

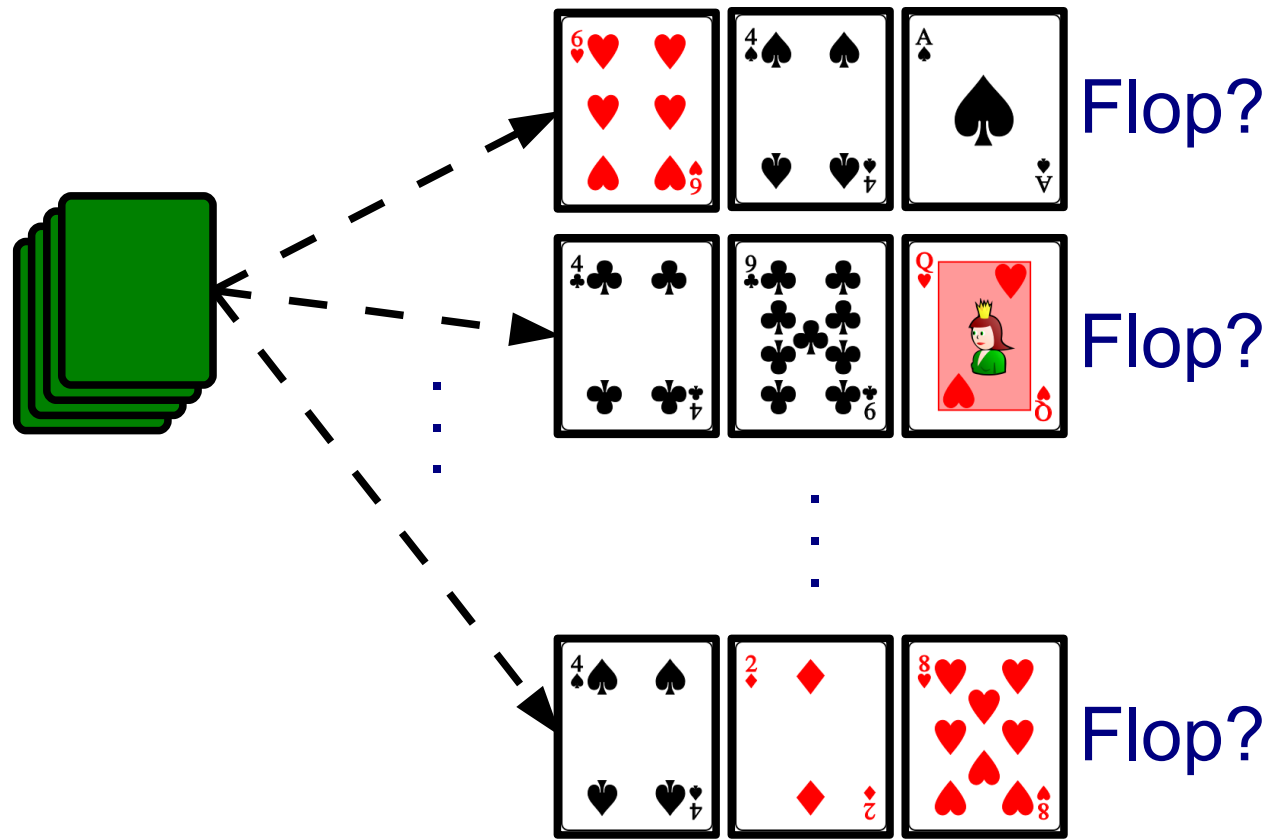
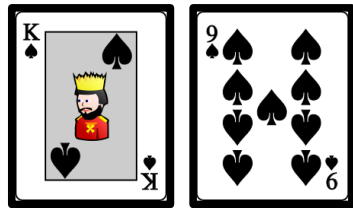
- Poker is challenging, thought-provoking, and most importantly, fun!
- ... but is that enough?



Source: maps.google.com

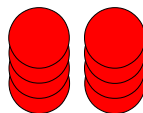
Why is Poker Interesting?

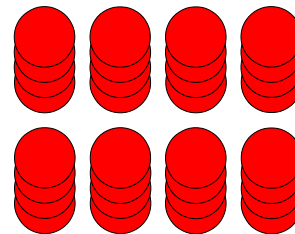
- Card deals introduce elements of chance.

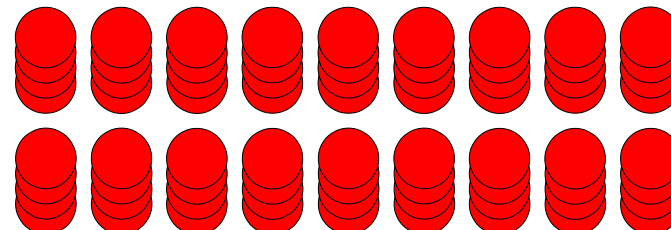


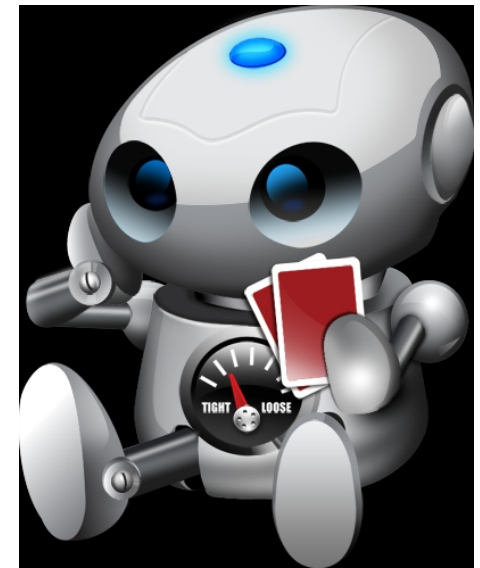
Why is Poker Interesting?

- Degree of winnings can vary.


Pot 1

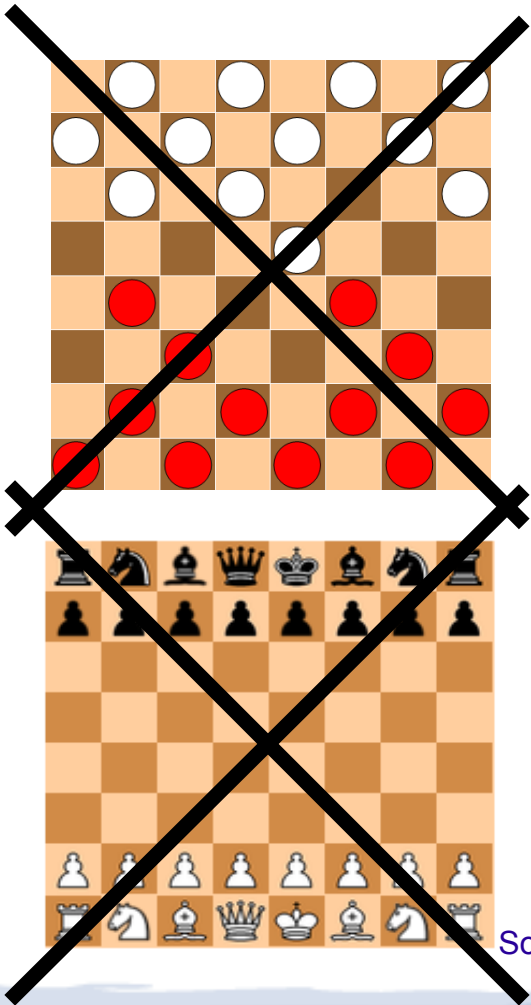

Pot 2


Pot 3



Why is Poker Interesting?

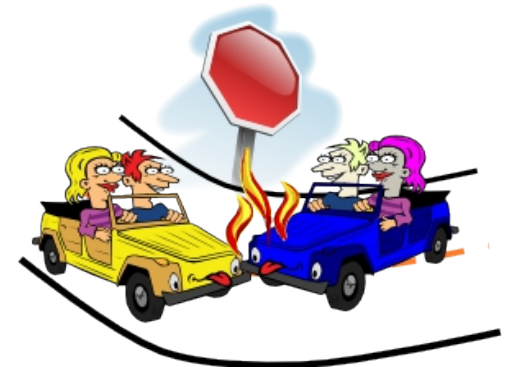
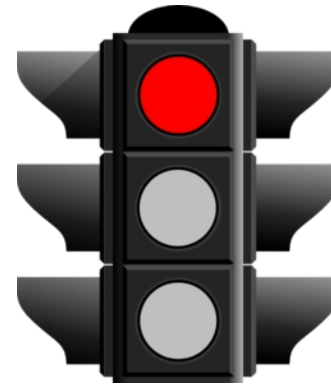
- Imperfect information!



Source: Wikipedia

Why is Poker Interesting?

- Poker decisions are analogous to real-life decisions.
Example: Driving a car.



Why is Poker Interesting?

- Poker decisions are analogous to real-life decisions.
Example: Online Advertisement Auctions.



Source: blog.revizzit.com

Why is Poker Interesting?

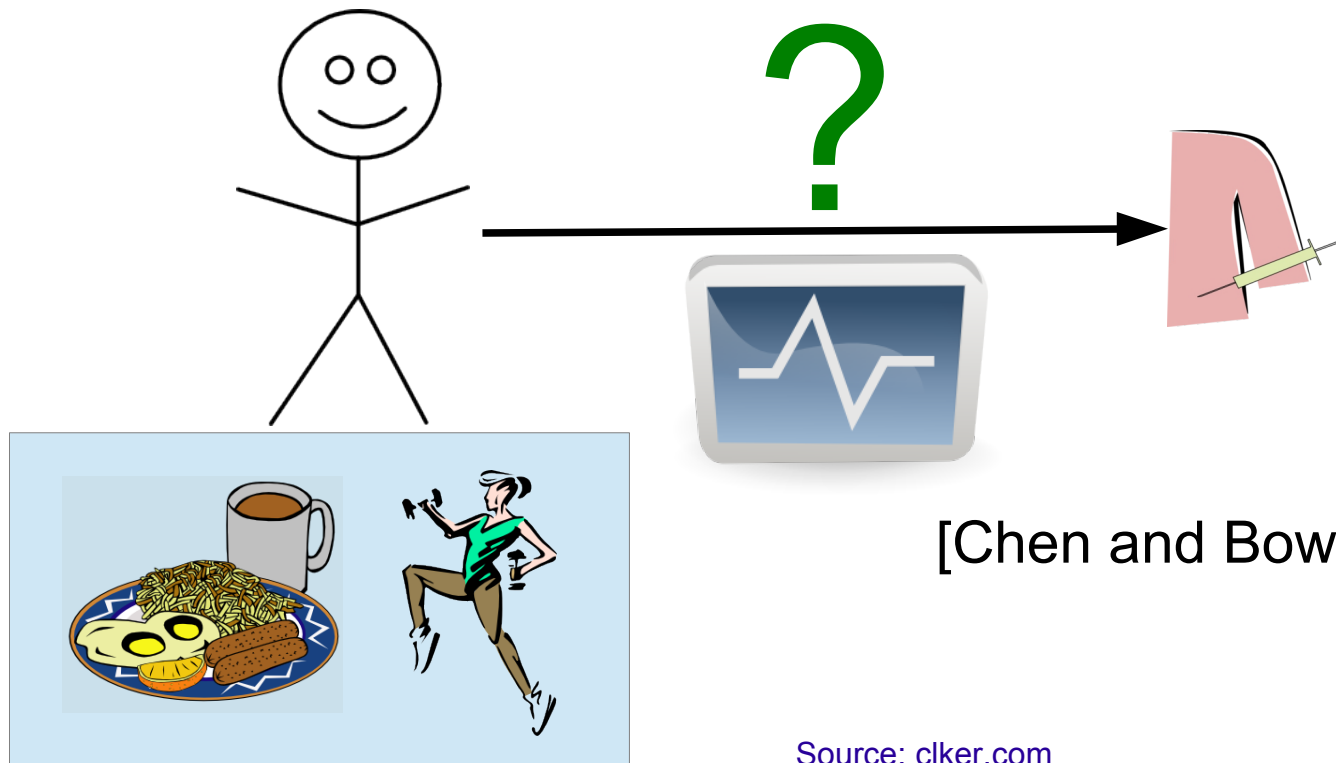
- Poker decisions are analogous to real-life decisions.
Example: Sequential Auctions.



Source: wikipedia.com

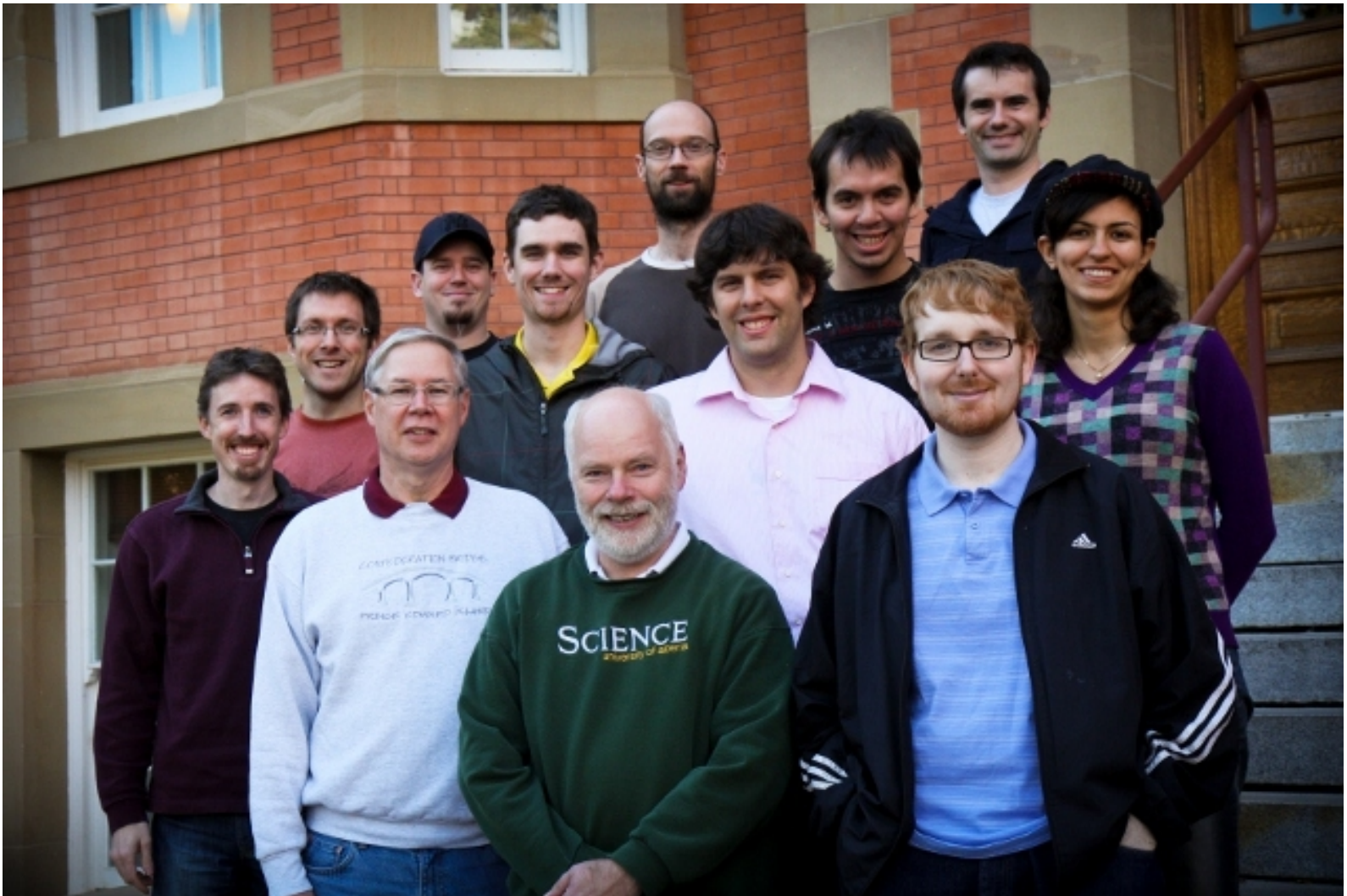
Why is Poker Interesting?

- Poker decisions are analogous to real-life decisions.
Example: “Adaptive Treatment Strategies”
 - For instance: Insulin for diabetes patients



[Chen and Bowling, NIPS 2012]

Computer Poker Research Group (CPRG)



Computer Poker Research Group (CPRG)

- Some of our old programs include:
 - **Loki** (1997)
 - **Poki** (1999)
 - **PsOpti / Sparbot** (2002)
 - **Vexbot** (2003)
- Limit Texas Hold'em
- Heads-up (2-player)
Limit Texas Hold'em



U of Alberta

Computer Poker Research Group (CPRG)

- Our current programs:
 - **Polaris** (vs. Humans)
 - **Hyperborean** (vs. Programs)
- Games we play:
 - Heads-up Limit Texas Hold'em
 - Heads-up No-limit Texas Hold'em
 - Three-player Limit Texas Hold'em



Computer Poker Research Group (CPRG)

- Our current programs:
 - **Polaris** (vs. Humans)
 - **Hyperborean** (vs. Programs)
- Games we play:
 - **Heads-up Limit Texas Hold'em**
 - Heads-up No-limit Texas Hold'em
 - Three-player Limit Texas Hold'em

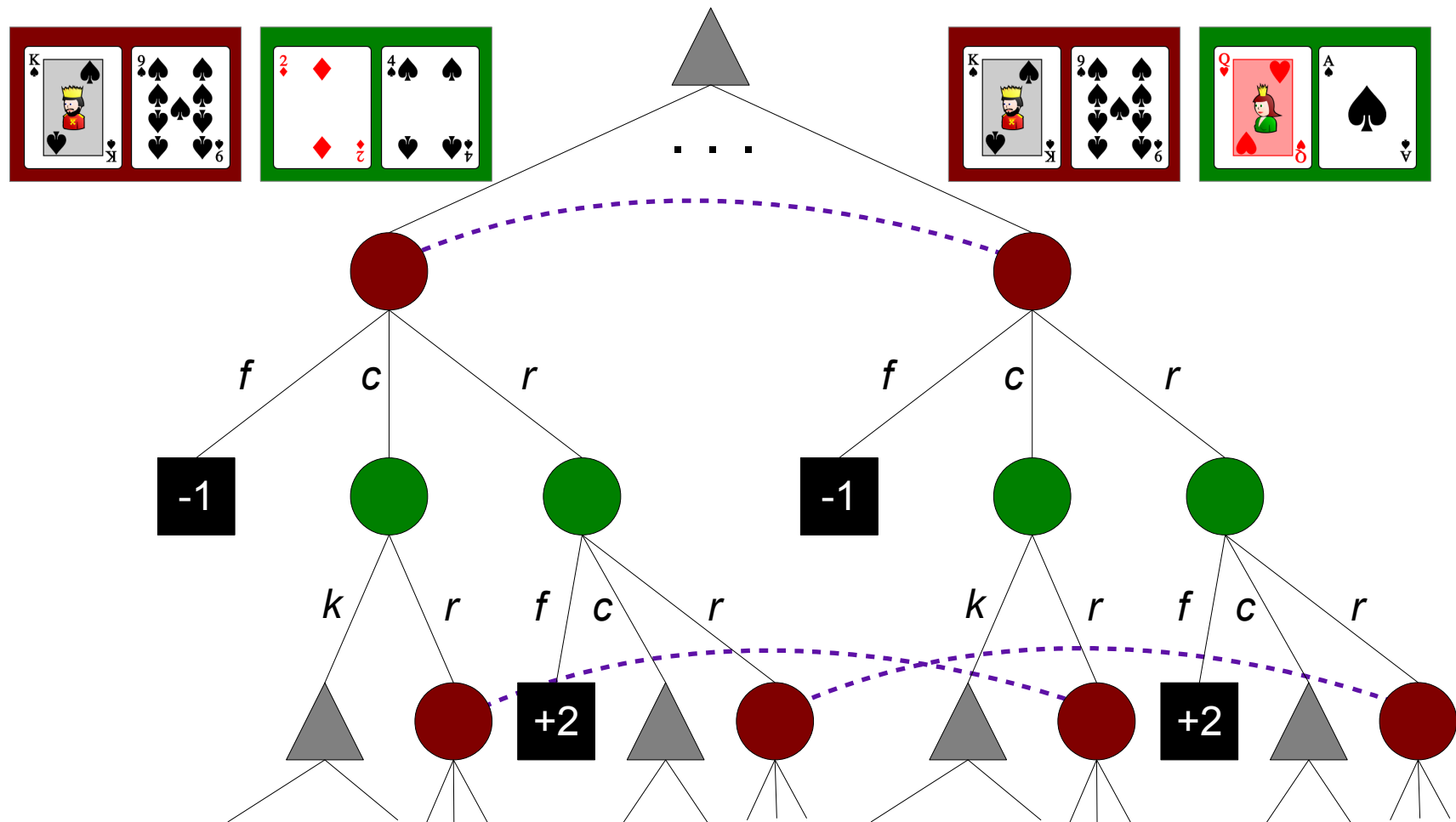


Overview

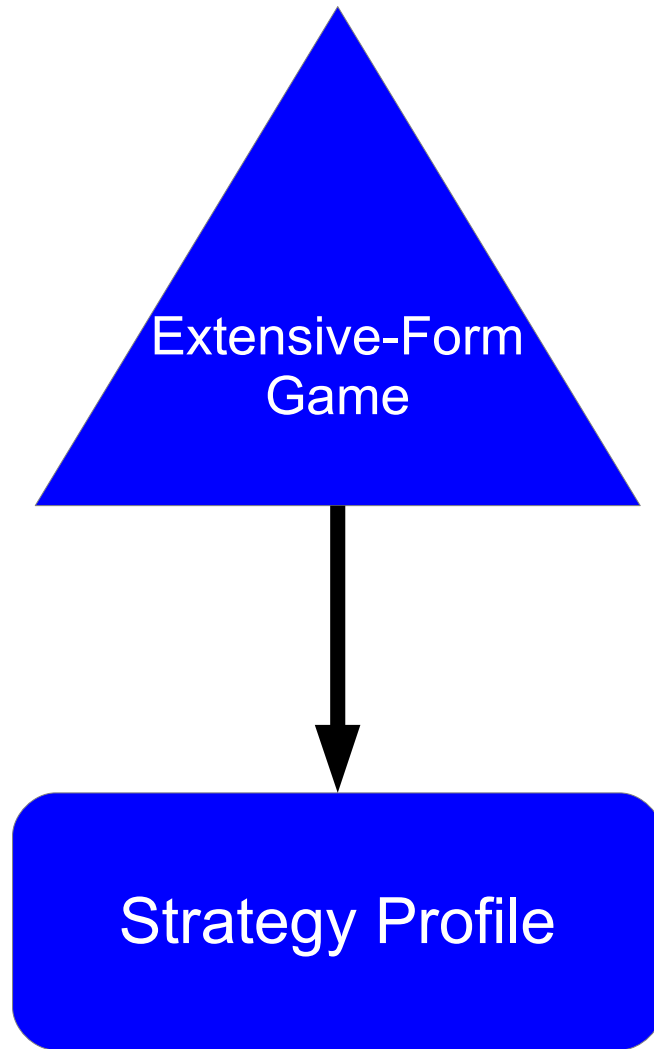
- Texas Hold'em
 - Why is poker research interesting?
 - Computer Poker Research Group
- **Creating Polaris, a poker-playing program**
 - **Nash equilibrium**
 - **Abstraction**
- Polaris in Action
 - Annual Computer Poker Competition (Programs vs. Programs)
 - Man vs. Machine Competitions
- Future Directions

Creating Polaris

- Model Texas Hold'em as an **extensive-form game**

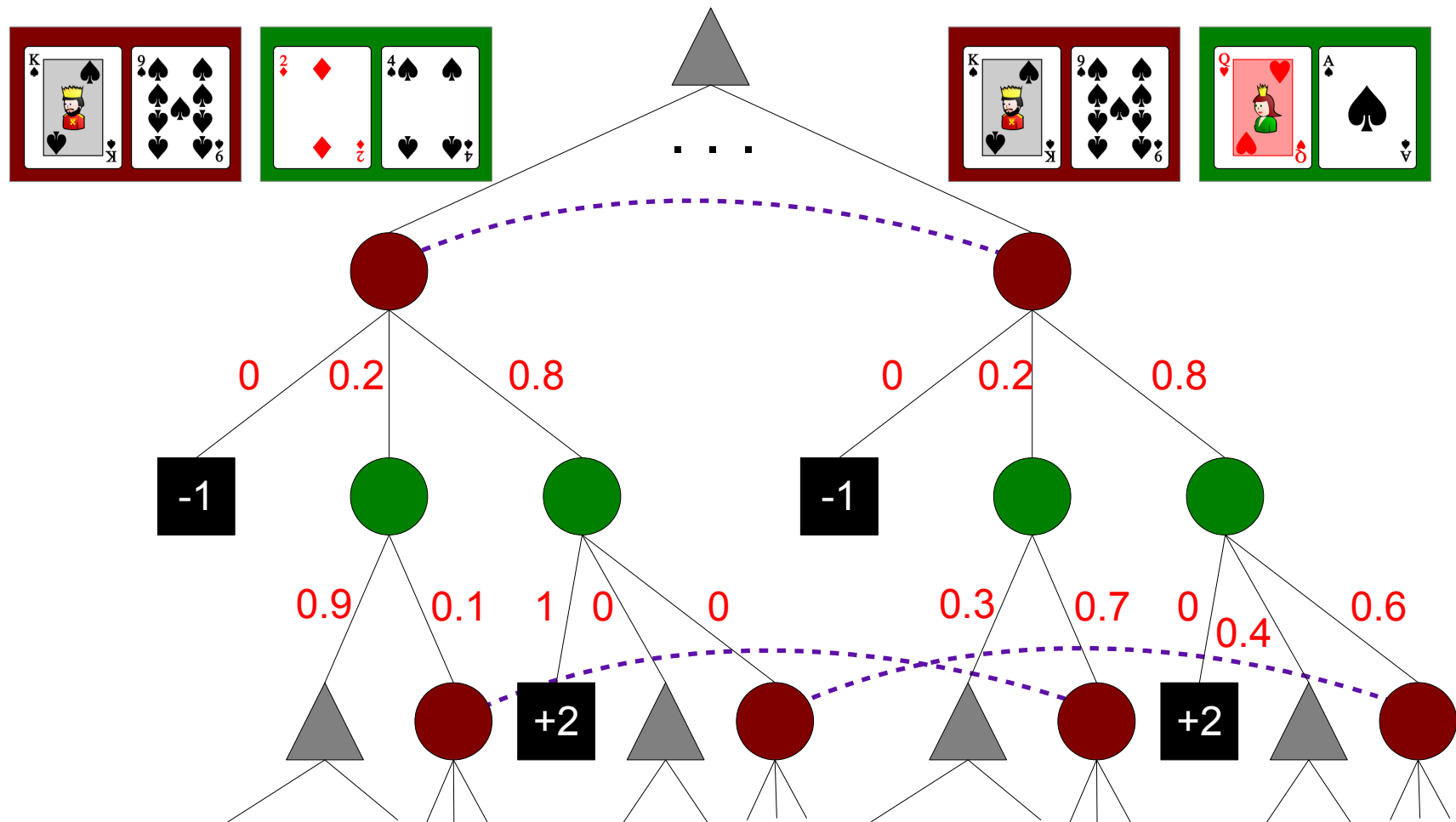


Creating Polaris



Creating Polaris

- A **strategy profile** provides probabilities for each action

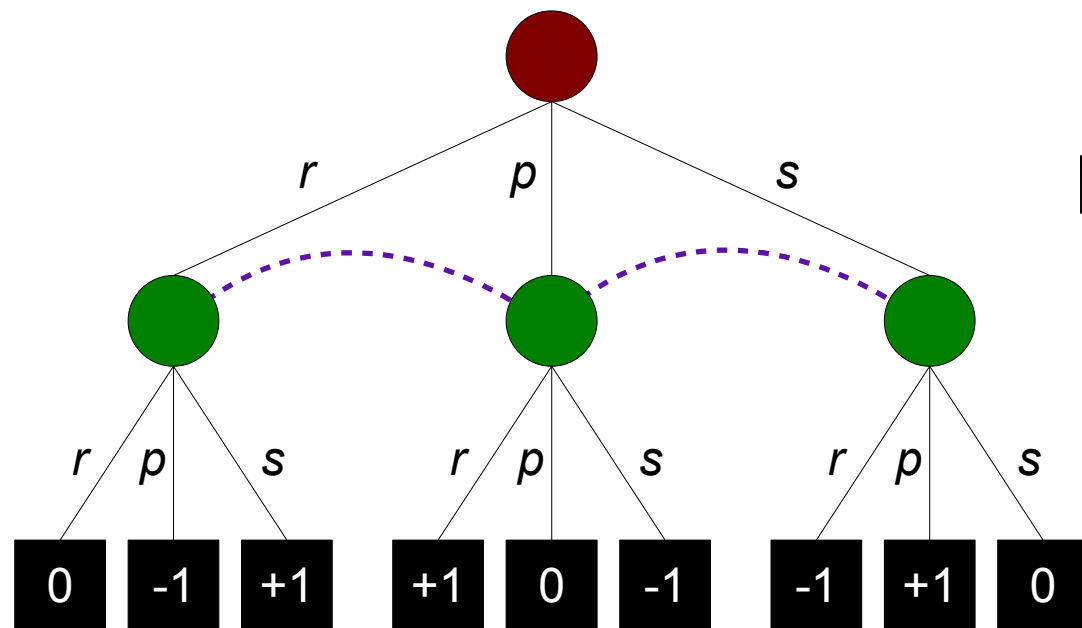


Creating Polaris

- What type of strategy profile do we want?
 - Nash equilibrium
- Example: Rock-Paper-Scissors

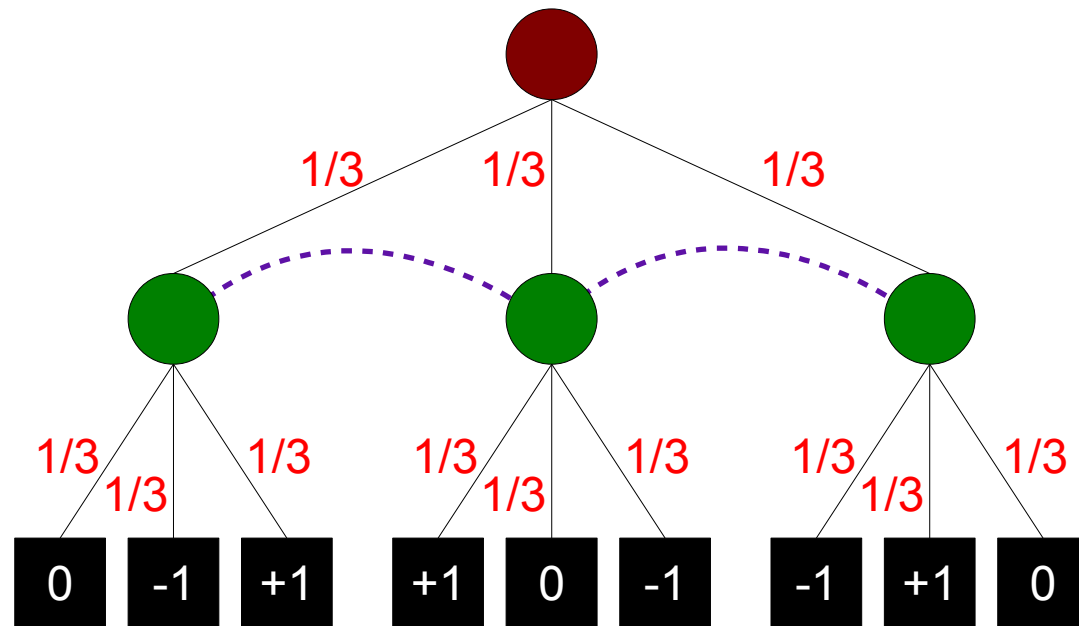


Creating Polaris



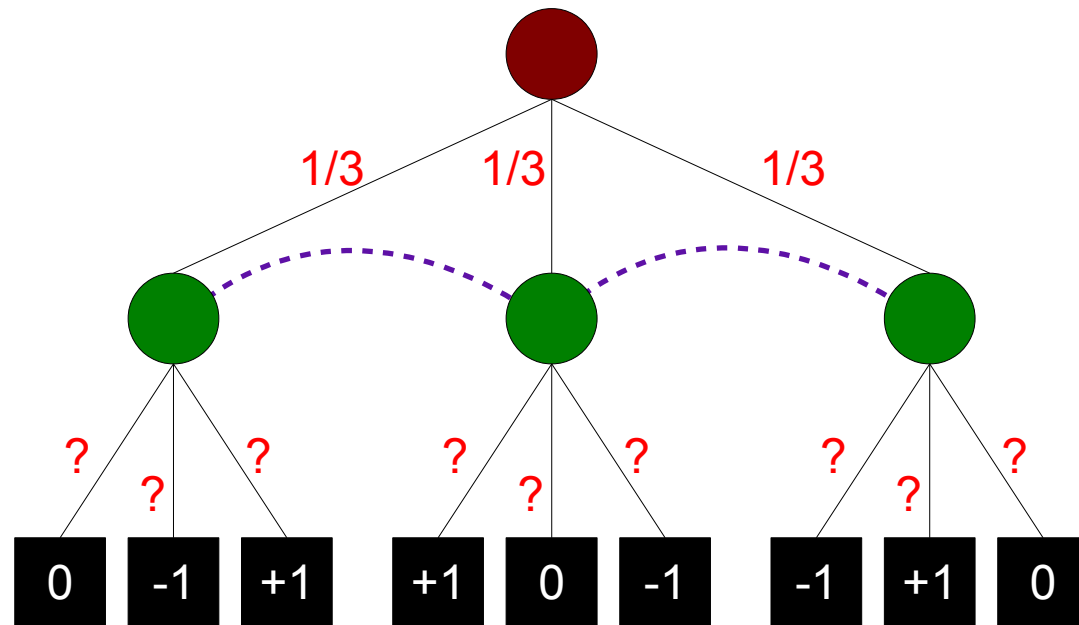
Creating Polaris

- A Nash equilibrium strategy profile for Rock-Paper-Scissors.
 - “No one can change their strategy and do better.”



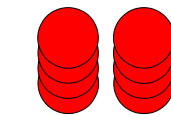
Creating Polaris

- A Nash equilibrium is a defensive strategy:
 - “I can't lose no matter what my opponent does.”

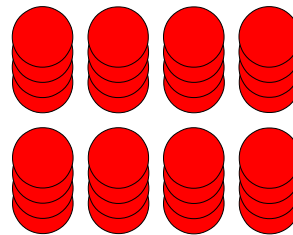


Creating Polaris

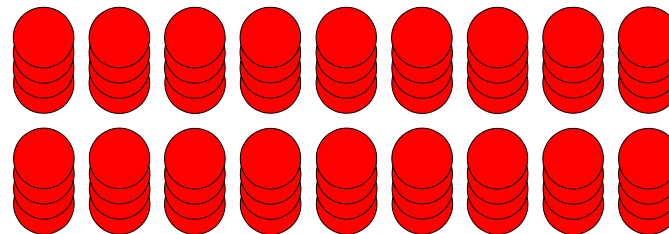
- But wait, you said we want to win as much as possible!



Pot 1



Pot 2



Pot 3

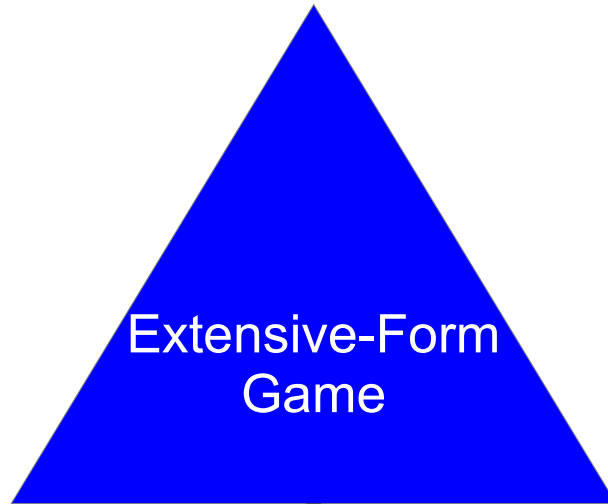


Creating Polaris

- But wait, you said we want to win as much as possible!
- Requires **opponent modelling**.
- Some progress made:
 - [Bard and Bowling, AAAI 2007]
 - [Johanson, Zinkevich, and Bowling, NIPS 2007]
 - [Johanson and Bowling, AISTATS 2009]

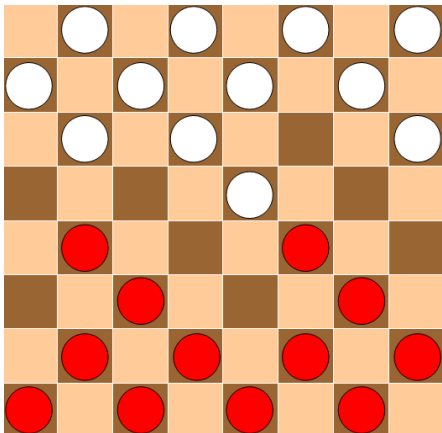
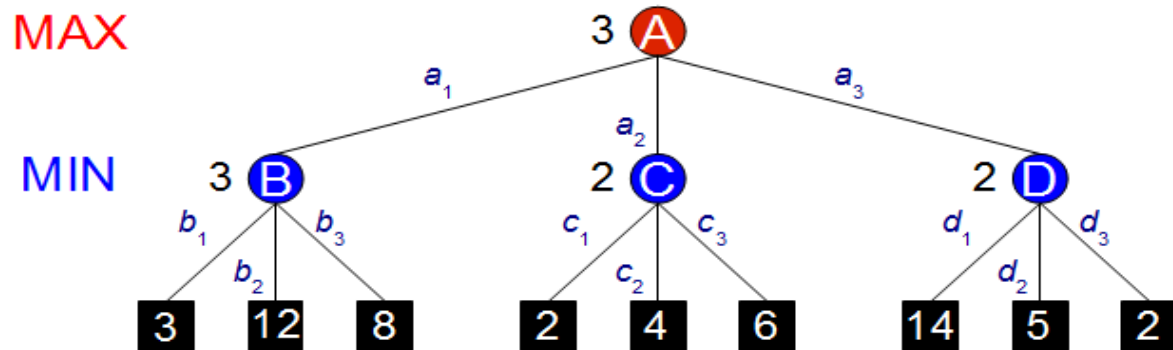
but still lots of work to be done!

Creating Polaris



Creating Polaris

- Use minimax (alpha-beta) search to compute Nash?

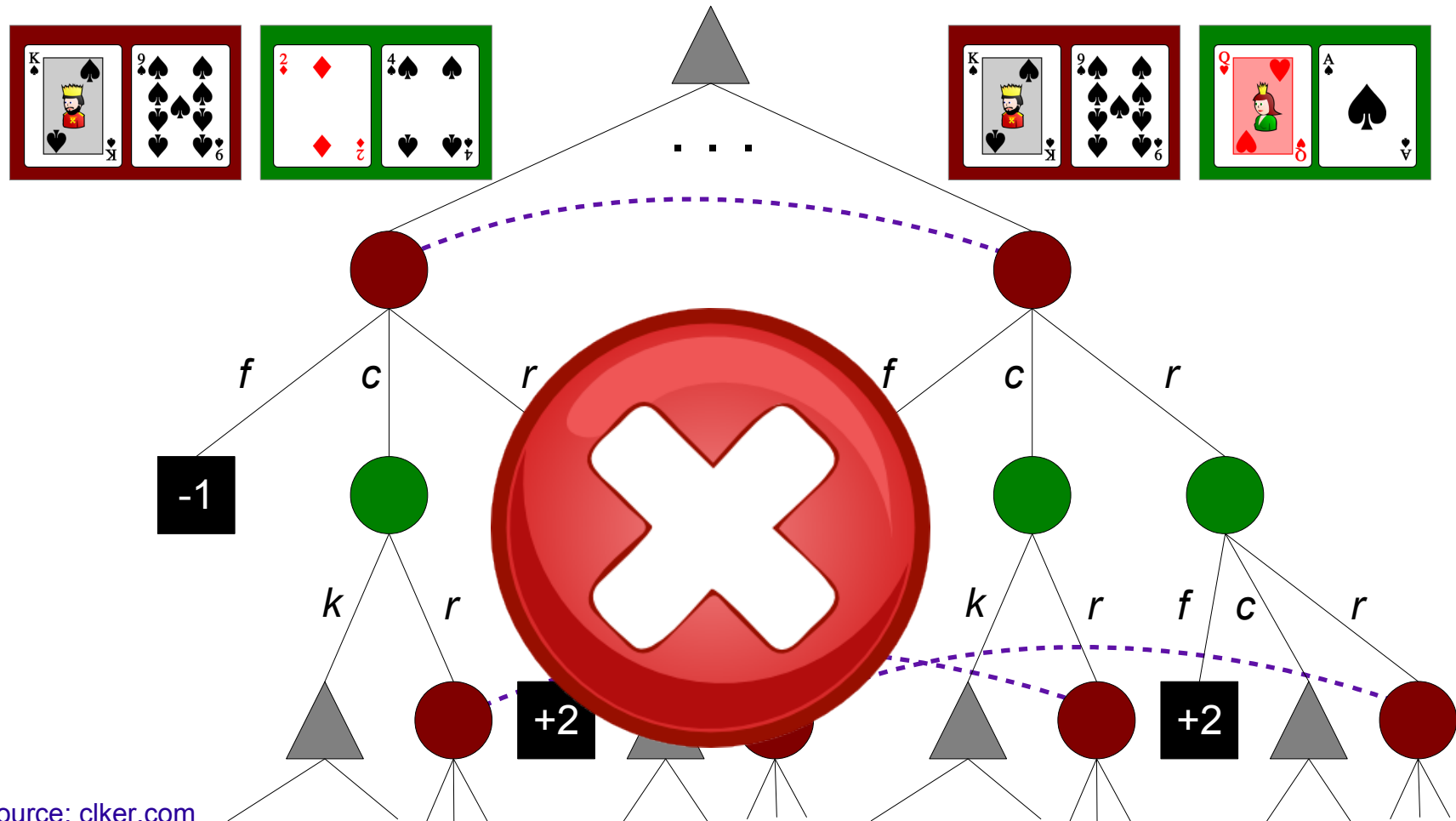


Source: clker.com



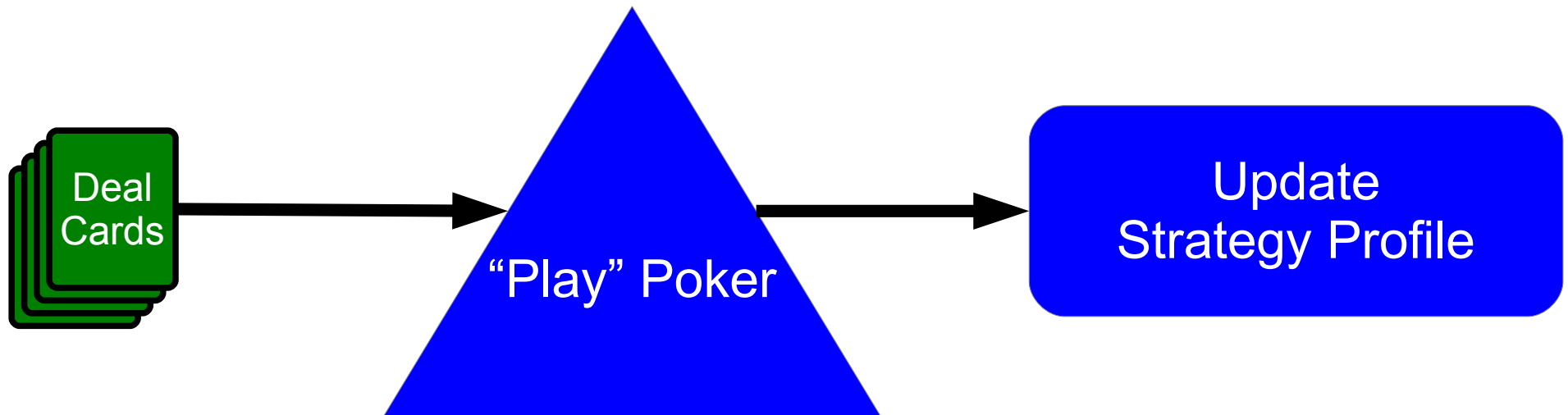
Creating Polaris

- Use minimax (alpha-beta) search?



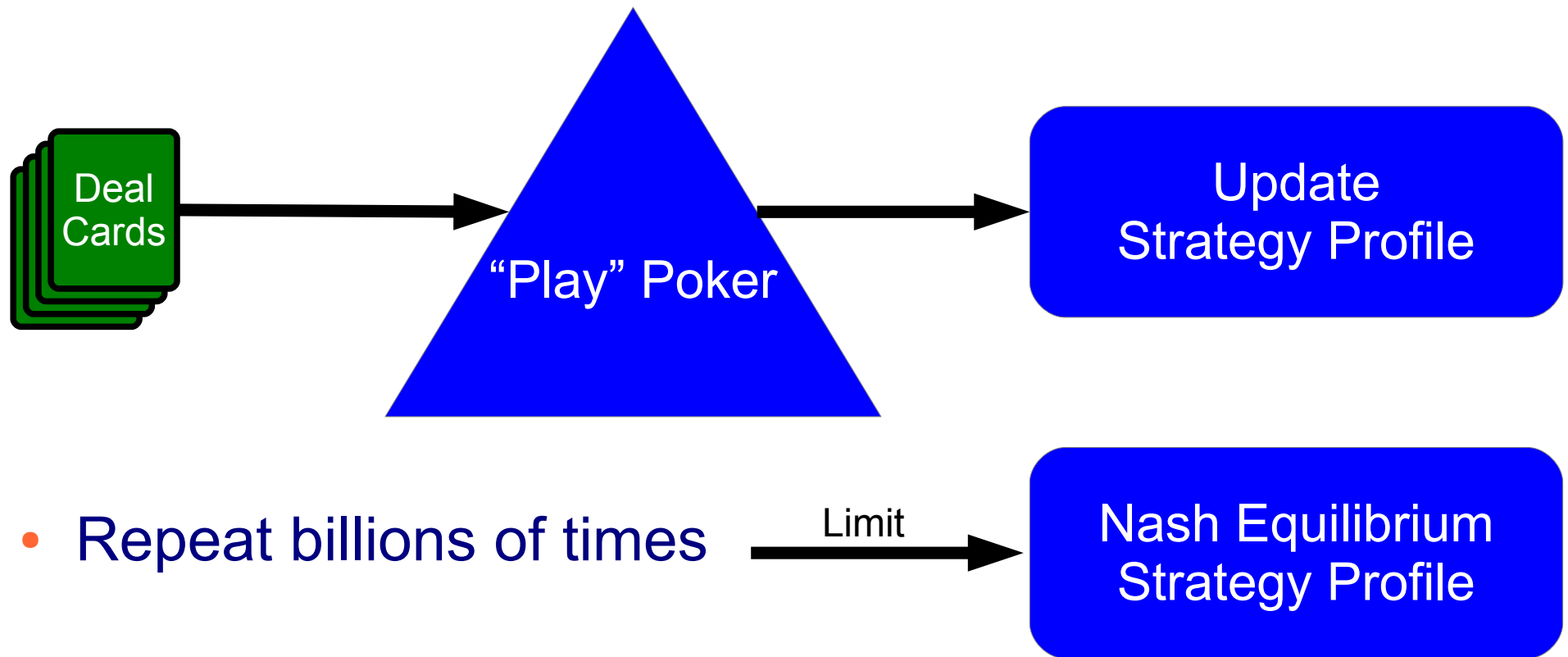
Creating Polaris

- Instead, use **Counterfactual Regret Minimization (CFR)** [Zinkevich *et al.*, NIPS 2007].



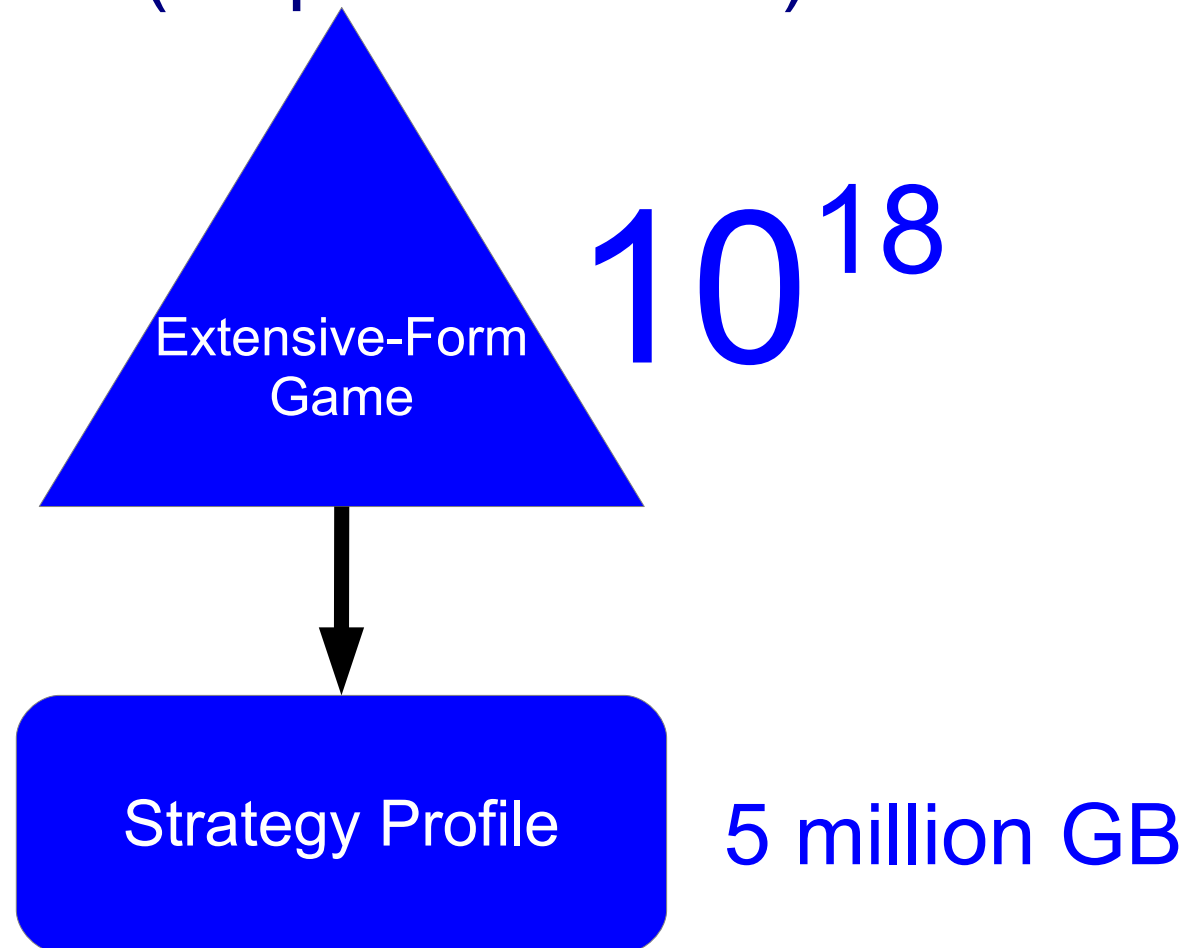
Creating Polaris

- Instead, use **Counterfactual Regret Minimization (CFR)** [Zinkevich *et al.*, NIPS 2007].



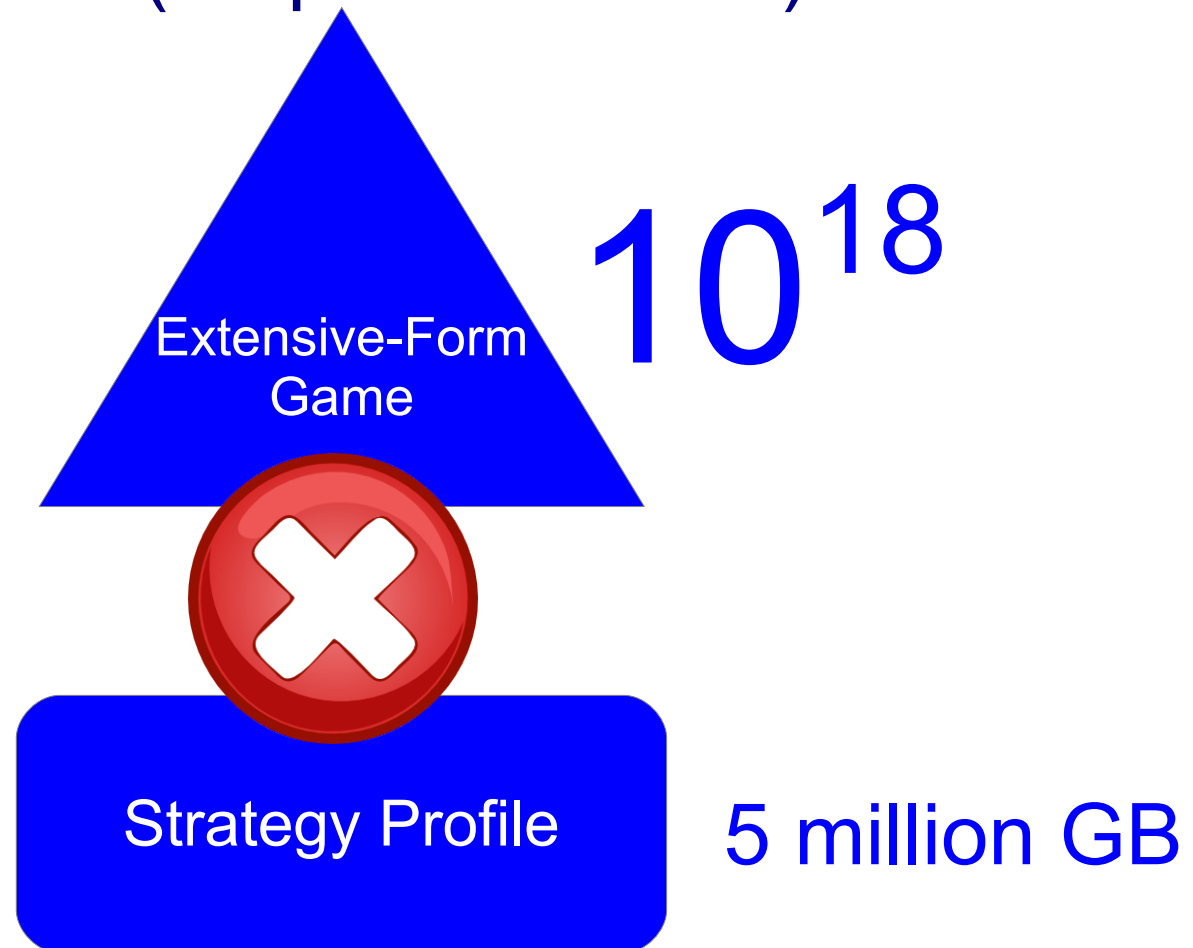
Creating Polaris

- “Huge” problem (no pun intended):

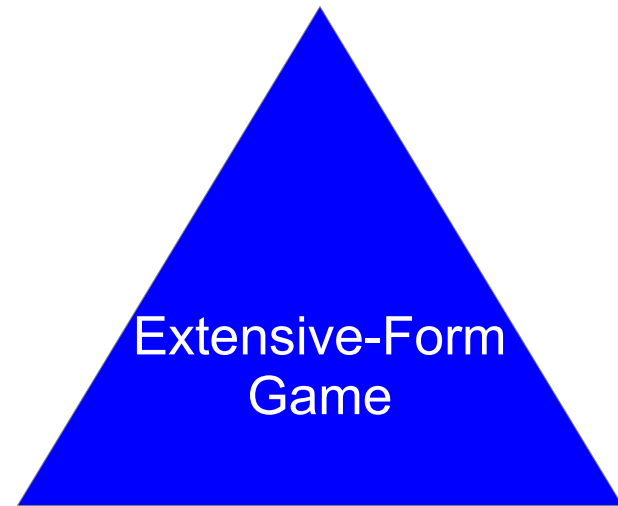


Creating Polaris

- “Huge” problem (no pun intended):



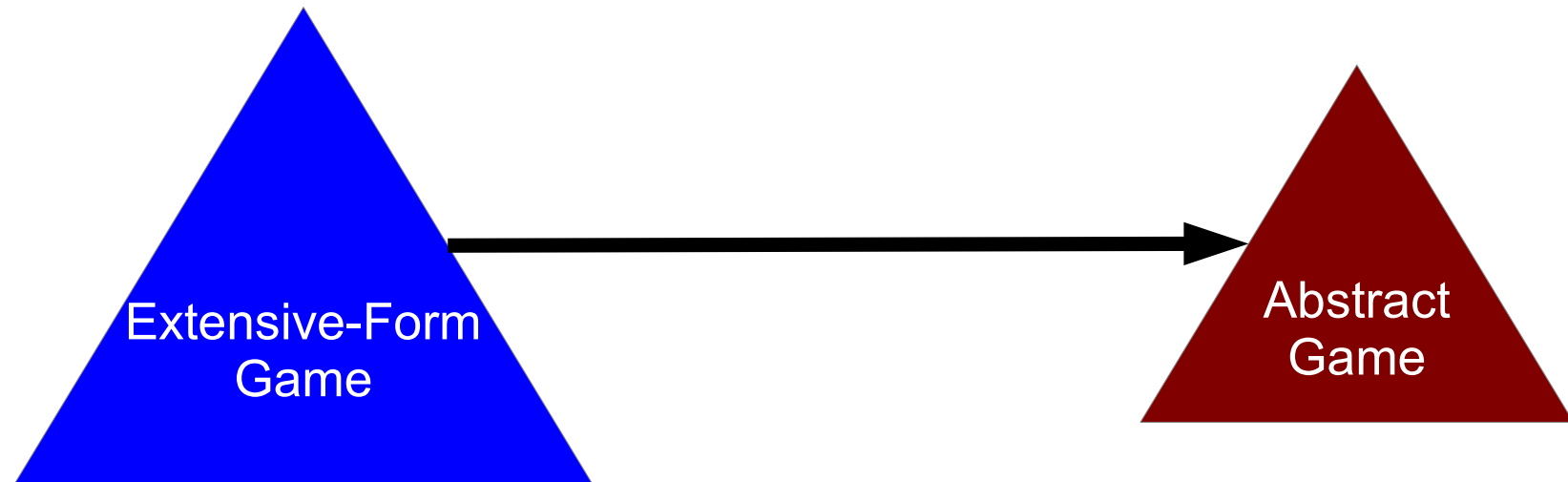
Creating Polaris



?

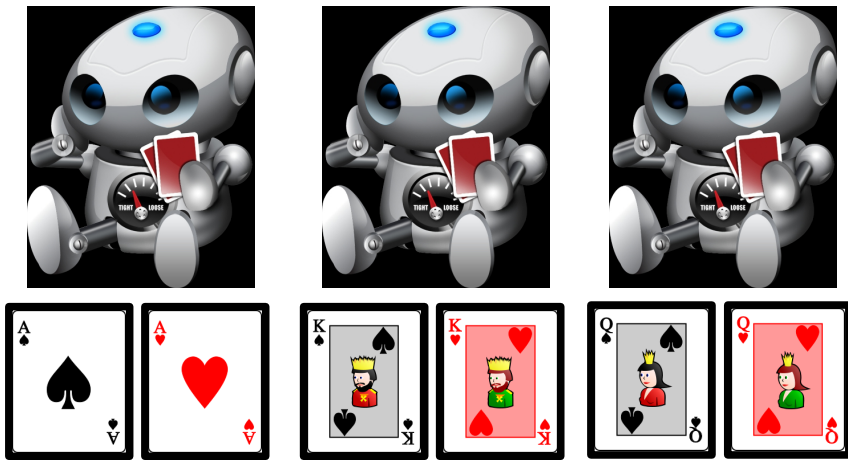
Nash Equilibrium
Strategy Profile

Creating Polaris

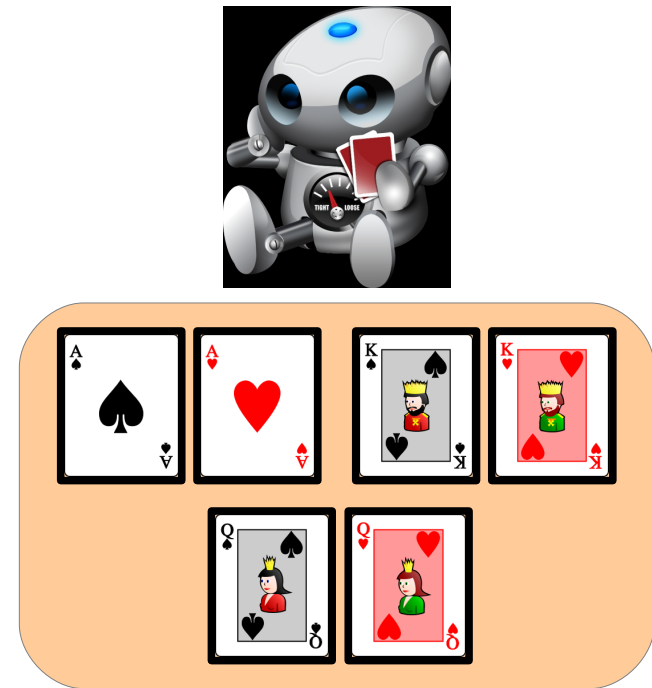


Creating Polaris

- Merge card deals into **buckets**.



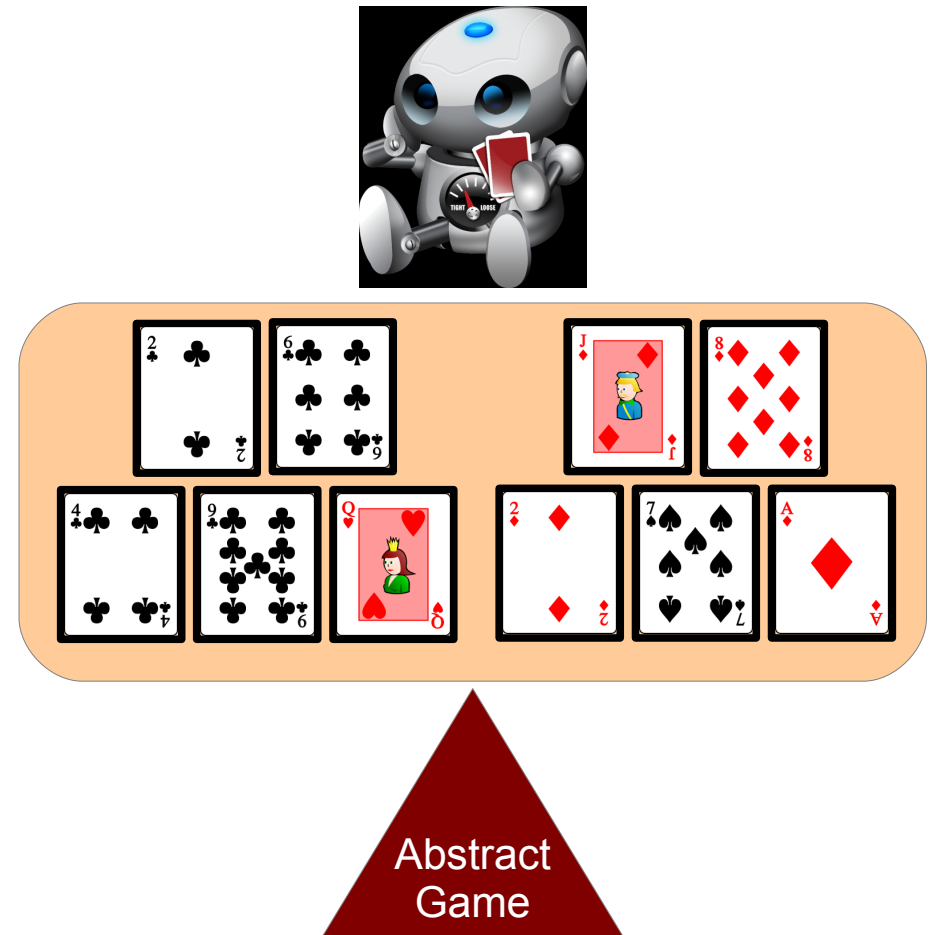
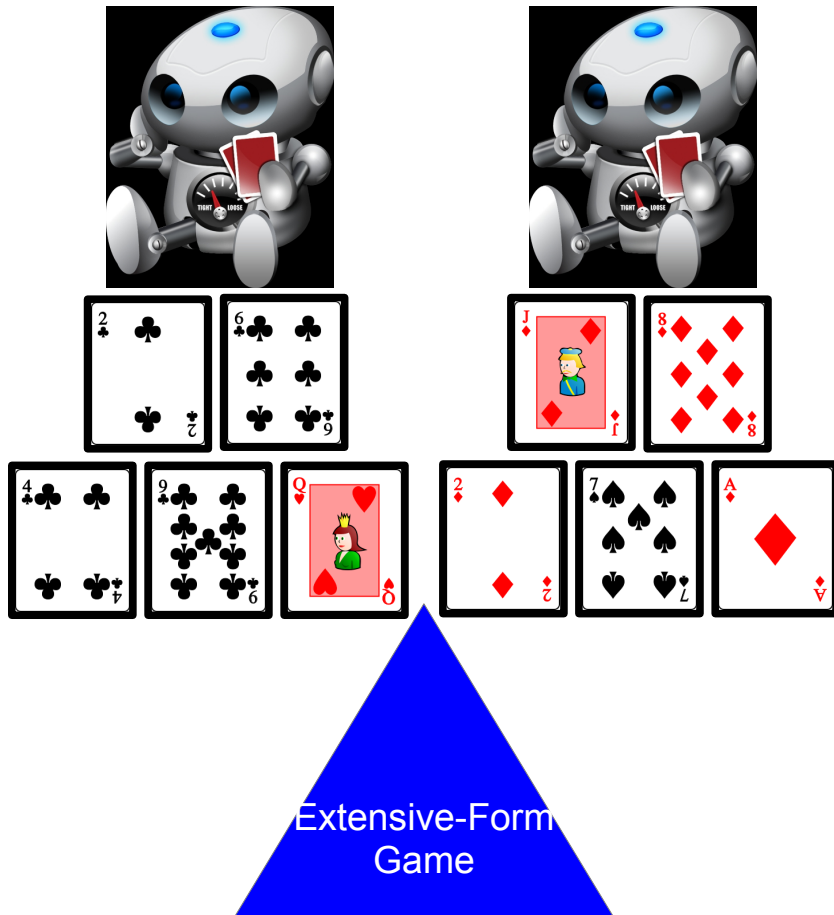
Extensive-Form
Game



Abstract
Game

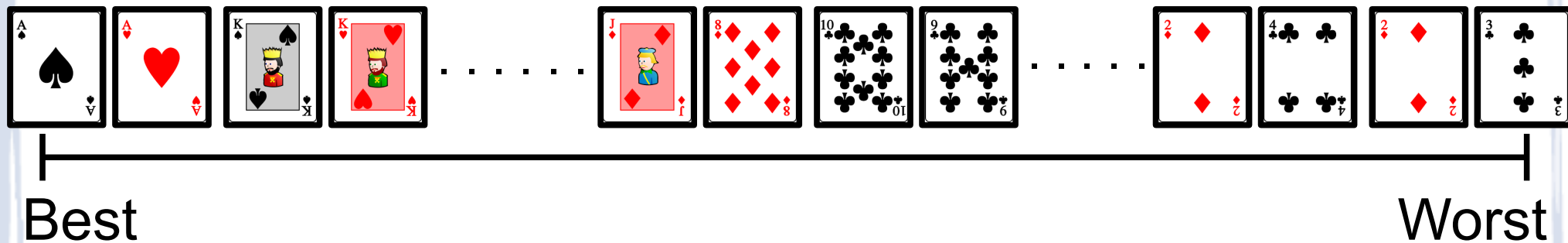
Creating Polaris

- Merge card deals into **buckets**.



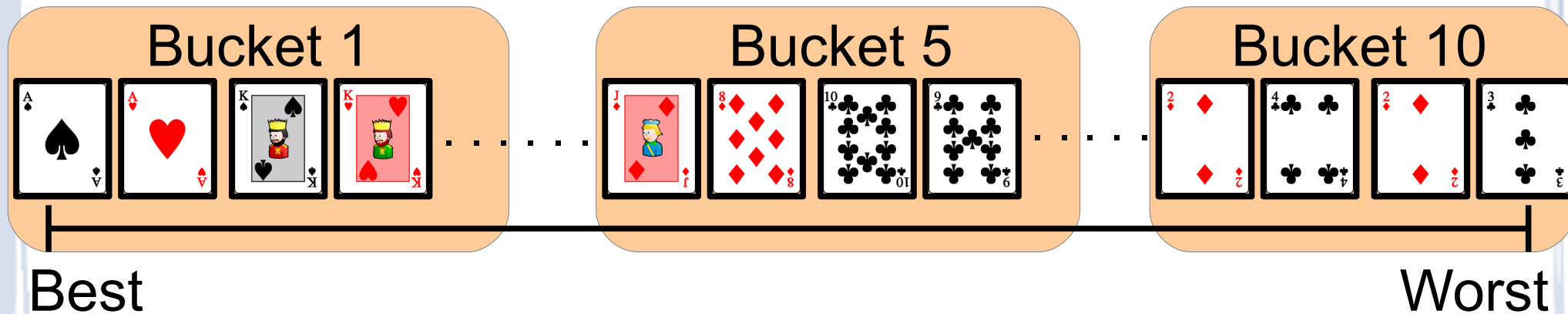
Creating Polaris

- Old technique: **Percentile Hand Strength**
 - Rank hands from best to worst.



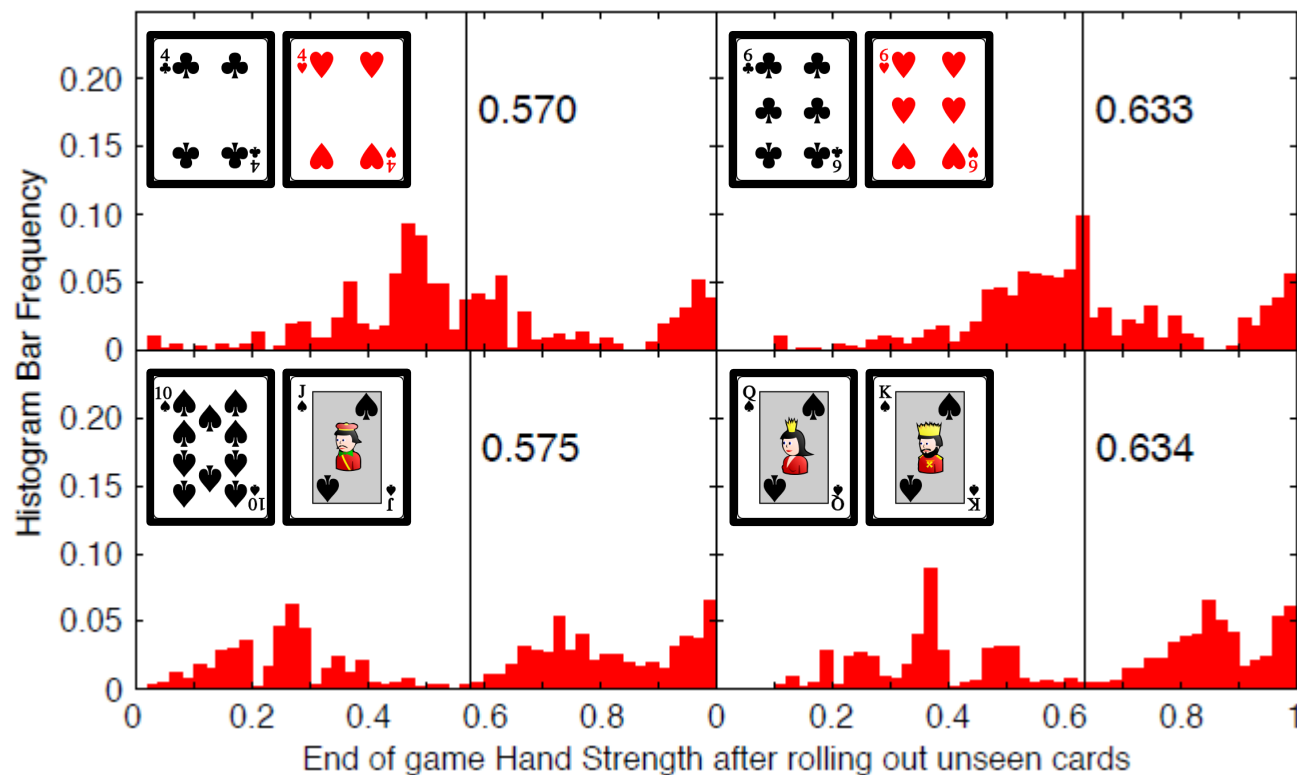
Creating Polaris

- Old technique: **Percentile Hand Strength**
 - Rank hands from best to worst.
 - For 10 buckets, put top 10% into bucket 1, next 10% into bucket 2, etc.



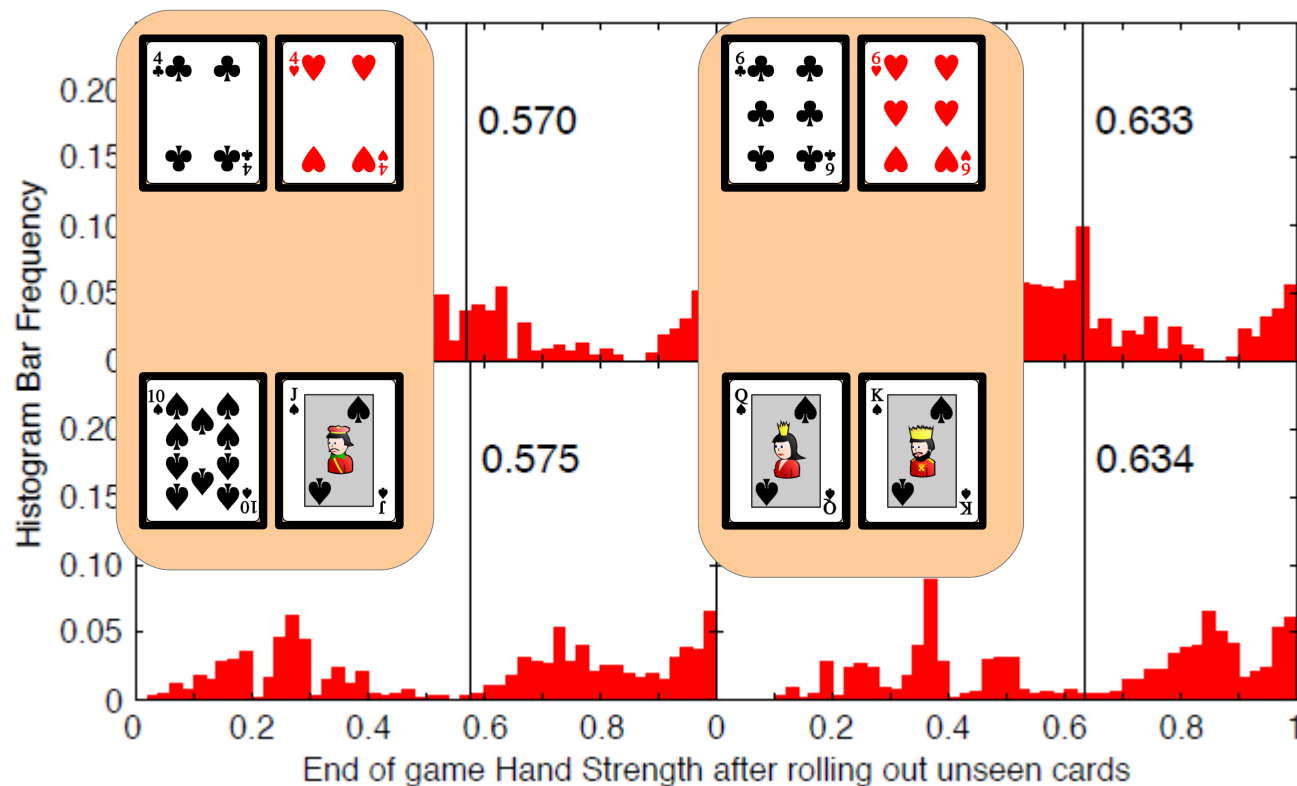
Creating Polaris

- New technique: Hand Strength Distribution Clustering



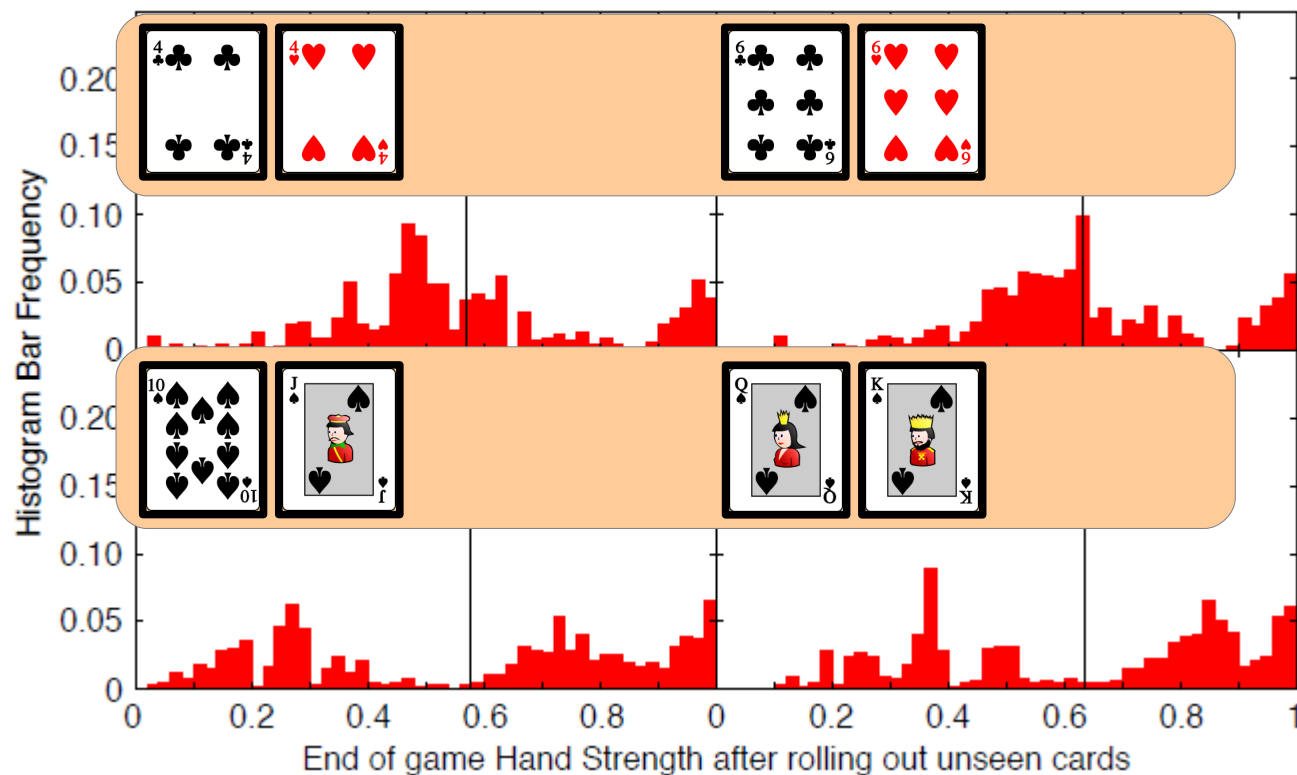
Creating Polaris

- New technique: **Hand Strength Distribution Clustering**
 - **Old bucketing technique**

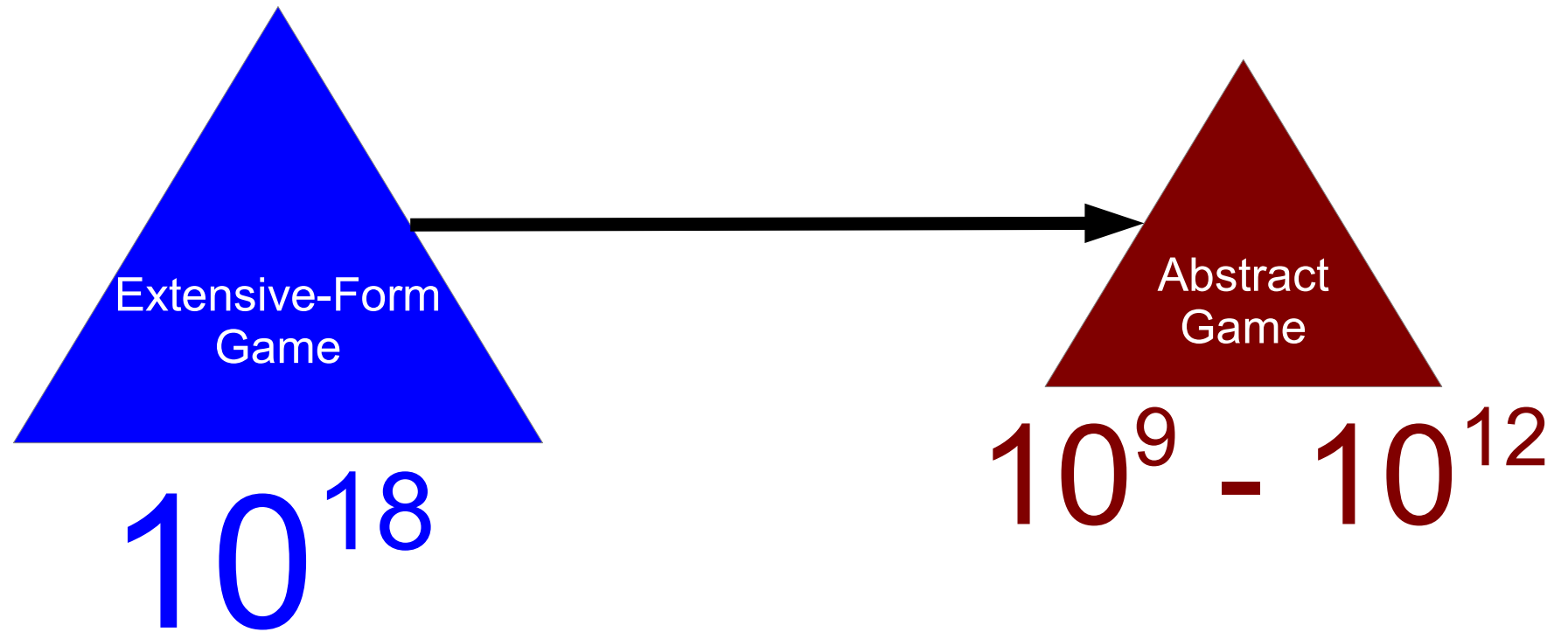


Creating Polaris

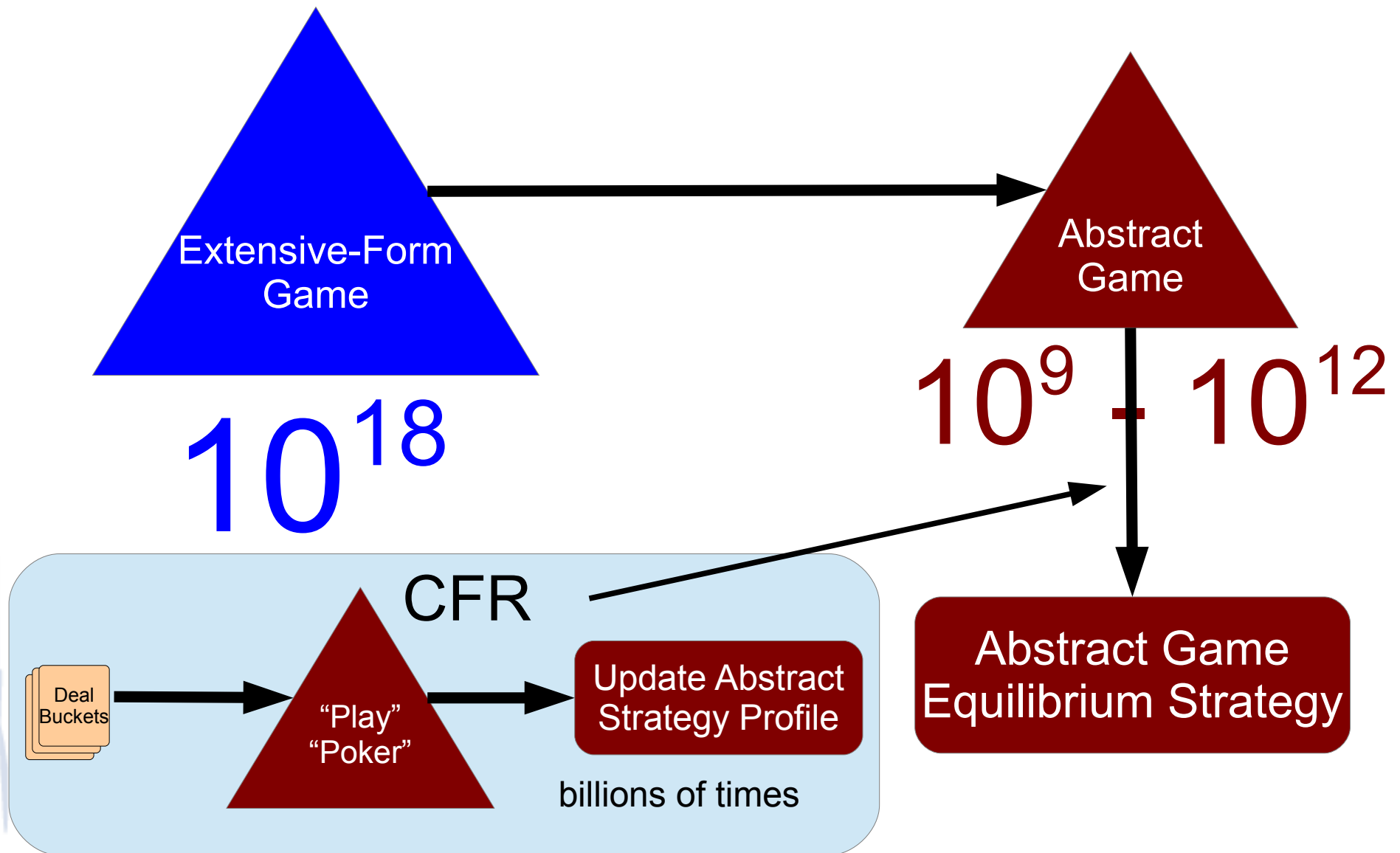
- New technique: Hand Strength Distribution Clustering
 - **New** bucketing technique



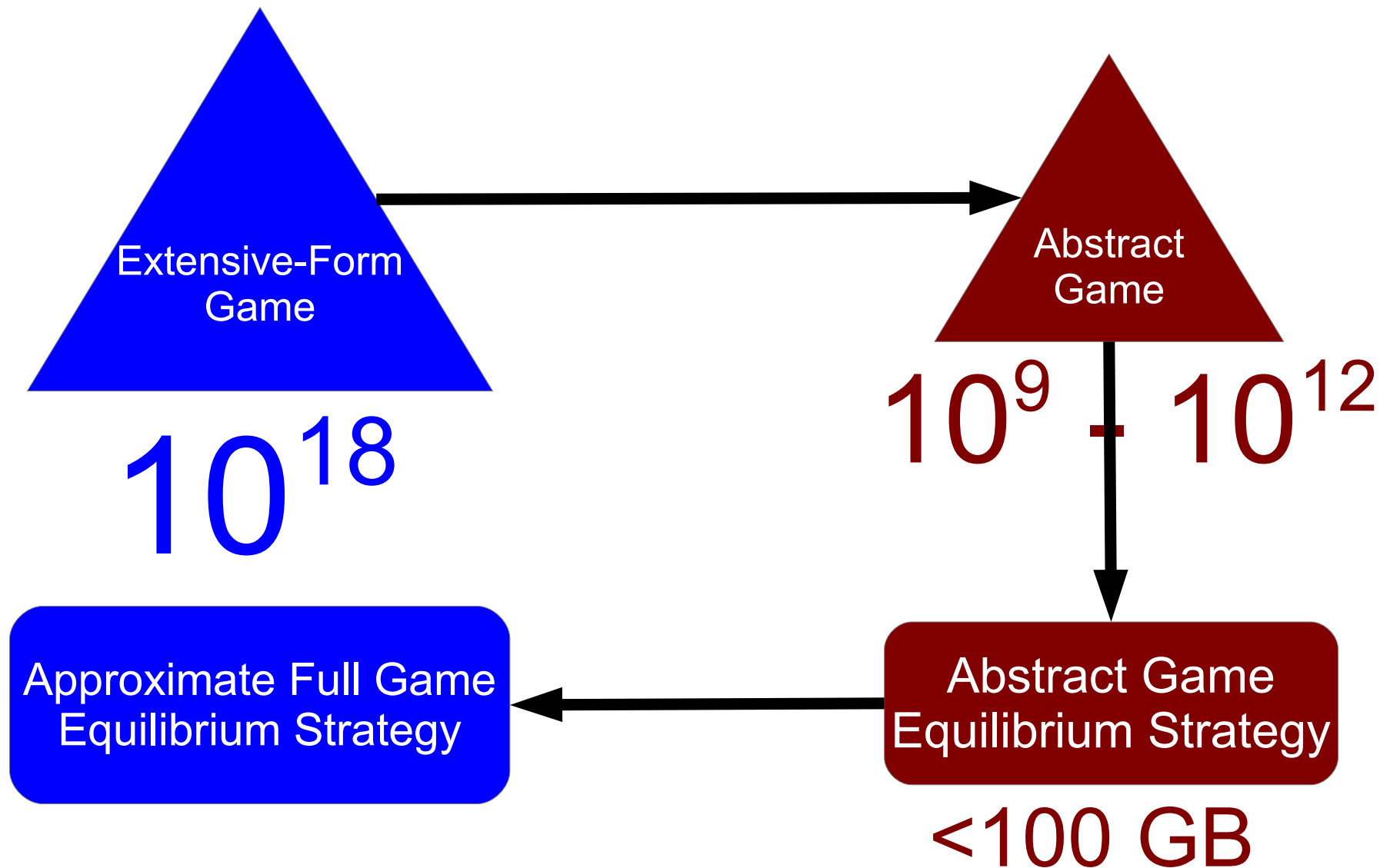
Creating Polaris



Creating Polaris



Creating Polaris



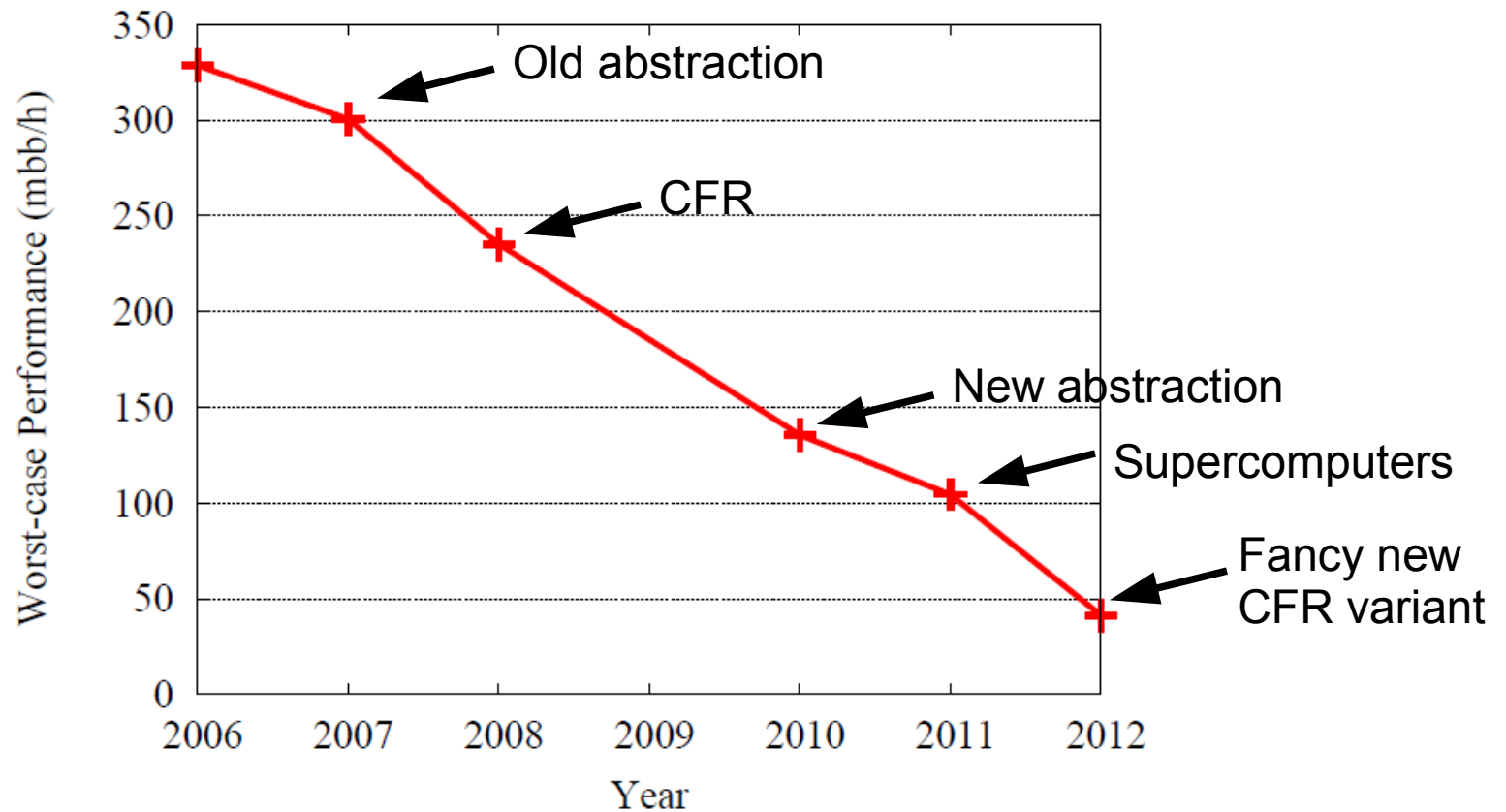
Creating Polaris

- How are these numbers still manageable?
 - We use Compute Canada's largest supercomputers.
 - Parallel implementations of abstraction, CFR.



Creating Polaris

- So how close to equilibrium are we?



Overview

- Texas Hold'em
 - Why is poker research interesting?
 - Computer Poker Research Group
- Creating Polaris, a poker-playing program
 - Nash equilibrium
 - Abstraction
- **Polaris in Action**
 - **Annual Computer Poker Competition (Programs vs. Programs)**
 - **Man vs. Machine Competitions**
- Future Directions

Polaris / Hyperborean in Action

- Annual Computer Poker Competition
 - Programs vs. Programs.



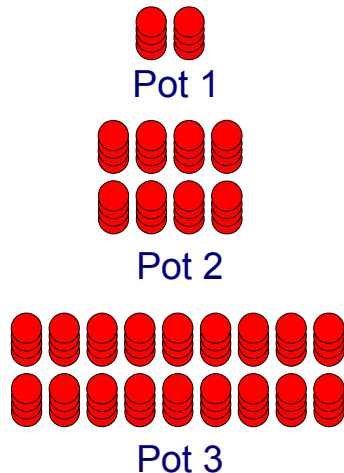
Polaris / Hyperborean in Action

- Annual Computer Poker Competition
 - Programs vs. Programs.
 - Three different Texas Hold'em games:
 - Heads-up limit
 - Heads-up no-limit
 - Three-player limit

Polaris / Hyperborean in Action

- Two divisions per game:

Total Bankroll



Bankroll Instant Run-off

Nash Equilibrium
Strategy Profile

Polaris / Hyperborean in Action

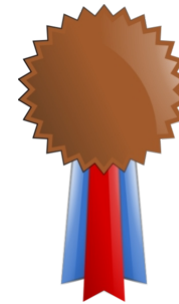
- Between 2006 – 2012:



21



8



5

Source: clker.com

- Placed in top 3 in 34 out of 35 events.
 - Finished 4th in 2012 Heads-up limit total bankroll.

Polaris / Hyperborean in Action

- 2007 Man vs. Machine Poker Competition:
 - Heads-up limit only
 - Opponents: Phil “The Unabomber” Laak and Ali Eslami.



VS.



Polaris / Hyperborean in Action

- Phil Laak during his second session against Polaris:
 - [Youtube Video](#)

Polaris / Hyperborean in Action

- Humans were victorious with narrow victory.
 - 500 duplicate hands per session, \$10/\$20 blinds

	Ali Eslami	Phil Laak	Combined Human Score	Results
Session 1	+\$395	-\$465	-\$70	Statistical Draw
Session 2	-\$2495	+\$1570	-\$925	Polaris Wins
Session 3	-\$635	+\$1455	+\$820	Humans Win
Session 4	+\$460	+\$110	+\$570	Humans Win
Overall	-\$2275	+\$2670	+\$395	Humans Win

Polaris / Hyperborean in Action

- 2008 Man vs. Machine Poker Competition
 - Again, just heads-up limit
 - Opponents: Matt Hawrilenko, Ijay Palansky, Nick Grudzien, Kyle Hendon, Rich McRoberts, Victor Acosta, Mark Newhouse



VS.



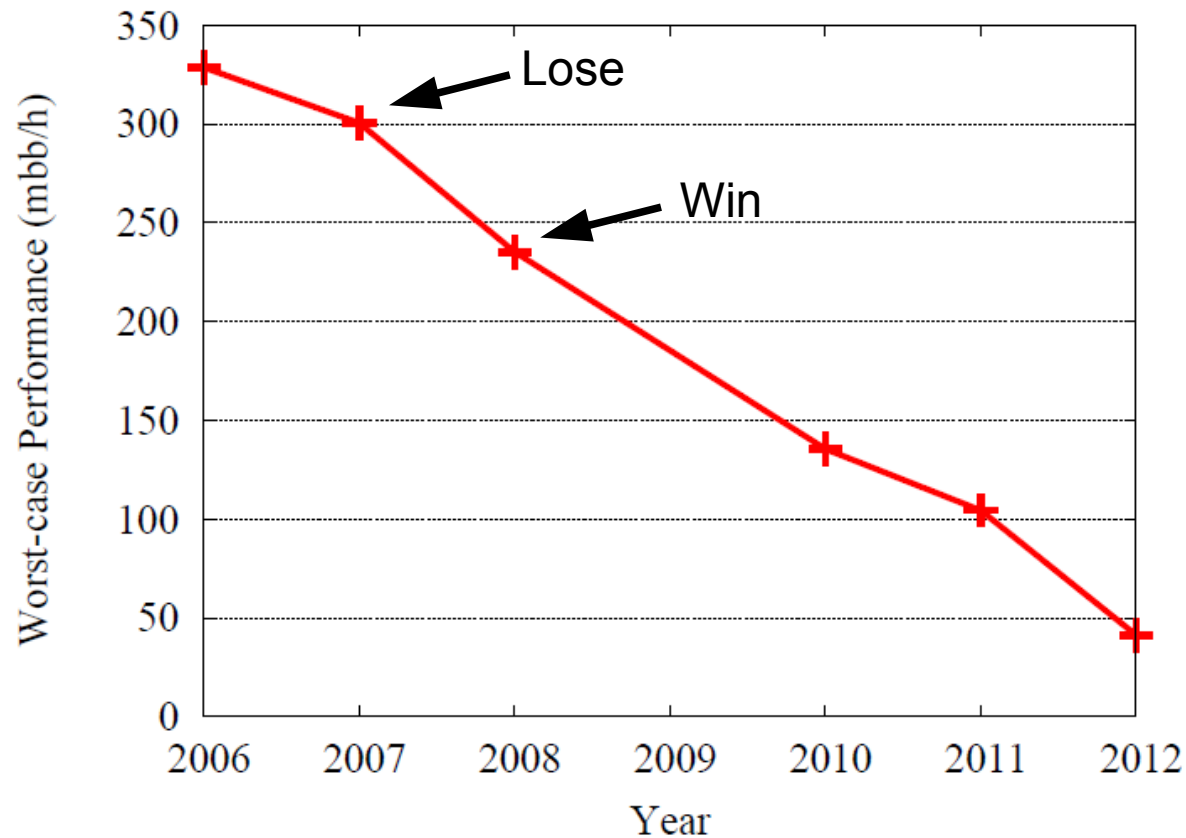
Polaris / Hyperborean in Action

- Polaris wins in rematch against humans!
 - 500 duplicate hands per session, \$1000/\$2000 blinds

	Human 1	Human 2	Combined Human Score	Results
Session 1	+\$199,500	-\$174,000	+\$25,500	Humans Win
Session 2	-\$2000	-\$118,000	-\$120,000	Polaris Wins
Session 3	-\$42,000	+\$37,000	-\$5000	Statistical Draw
Session 4	+\$89,500	-\$39,500	+\$50,000	Humans Win
Session 5	+\$251,500	-\$307,500	-\$56,000	Polaris Wins
Session 6	-\$60,500	-\$29,000	-\$89,500	Polaris Wins
Overall	-	-	-\$195,000	Polaris Wins

Polaris / Hyperborean in Action

- Lost to humans in 2007 – beat humans in 2008!



Overview

- Texas Hold'em
 - Why is poker research interesting?
 - Computer Poker Research Group
- Creating Polaris, a poker-playing program
 - Nash equilibrium
 - Abstraction
- Polaris in Action
 - Annual Computer Poker Competition (Programs vs. Programs)
 - Man vs. Machine Competitions
- **Future Directions**

Future Directions

- Official heads-up no-limit man vs. Machine match?
 - We are still far from equilibrium in no-limit.
- Is there a better approach for three-player?
- Can we extend our techniques to max ten-player?
- Tournament poker?
- Better abstraction techniques?
- Can we “solve” heads-up limit Texas Hold'em?

Future Directions

- We need more students!



Future Directions

- We need more students!



Thanks for Listening!

- Computer Poker Research Group:
 - Website: <http://cs.ualberta.ca/~poker>
 - Twitter: @PolarisPoker
- My information:
 - Email: rggibson@cs.ualberta.ca
 - Website: <http://cs.ualberta.ca/~rggibson>
 - Twitter: @RichardGGibson

