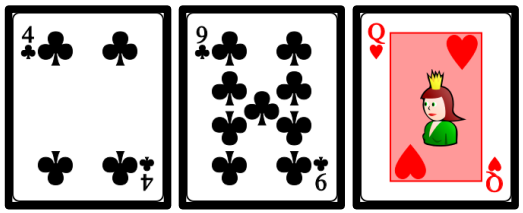
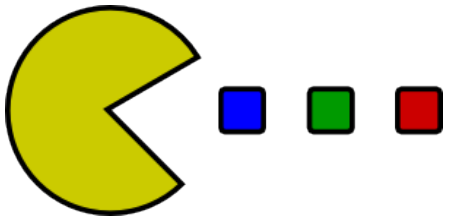
Recent Advances in Computer Poker and Future Research for Artificial Intelligence in Video Games





Richard Gibson

SIAT Faculty Search Presentation

February 28, 2013

Alberta Innovates

NSERC CRSNG

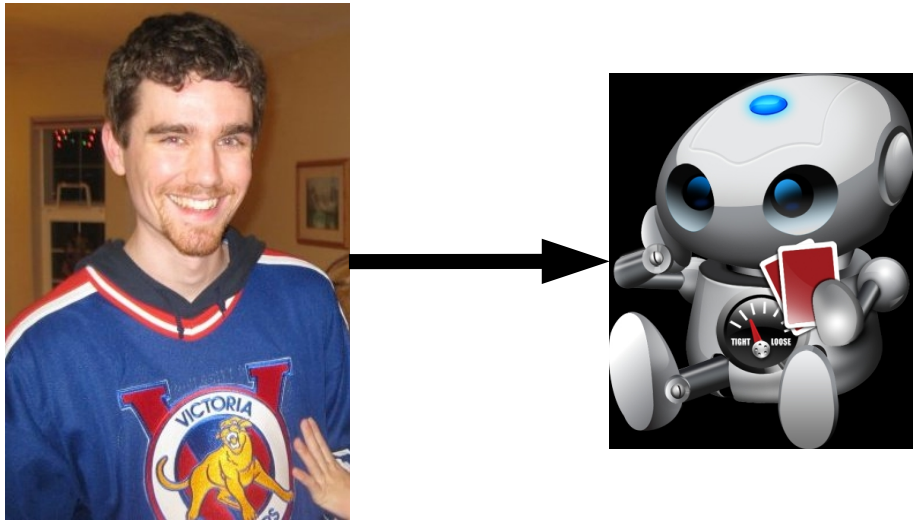
University of Alberta

compute • calcul CANADA

WestGrid

One Slide Summary

- 2009 – 2013: Computer Poker Research



One Slide Summary

- 2009 – 2013: Computer Poker Research
- Future: AI in Video Games

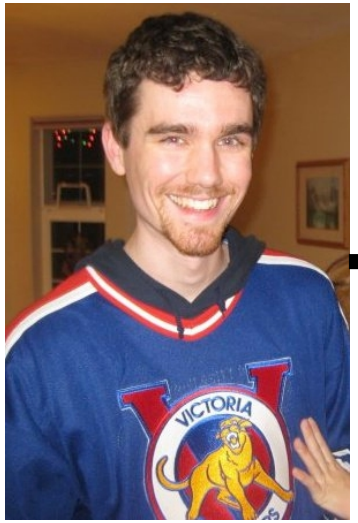


Image source: co-optimus.com

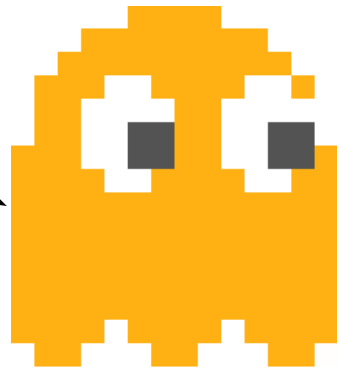


Image source: arcadelearningenvironment.org

Outline of Presentation

- Computer Poker Primer
  - Motivation
  - Background
- New Contributions to Computer Poker
  - Research + Hyperborean3p
- Future Research – AI in Video Games
  - StarCraft AI, ALE, automated content generation
- Teaching Interests
  - Game design, AI in video games

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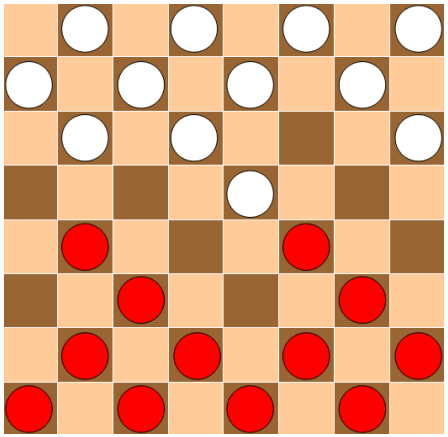
Why Poker Research?

- Classic games, such as chess and checkers, are:
  - Deterministic
  - Binary outcomes (+ draw)
  - Perfect Information



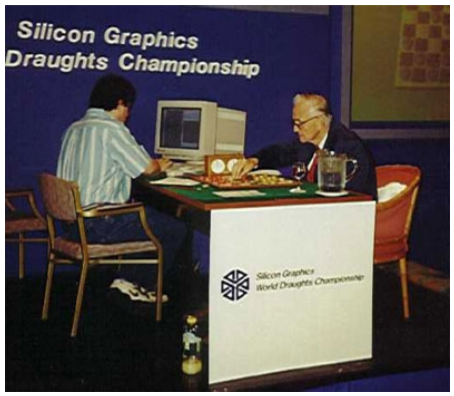


Image source: spectrum.ieee.org

Image sources: Wikipedia

Why Poker Research?

- However, poker is a game with:
  - Stochastic elements

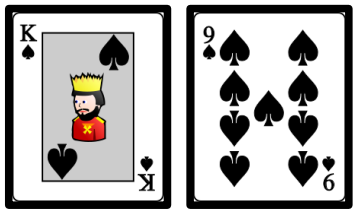
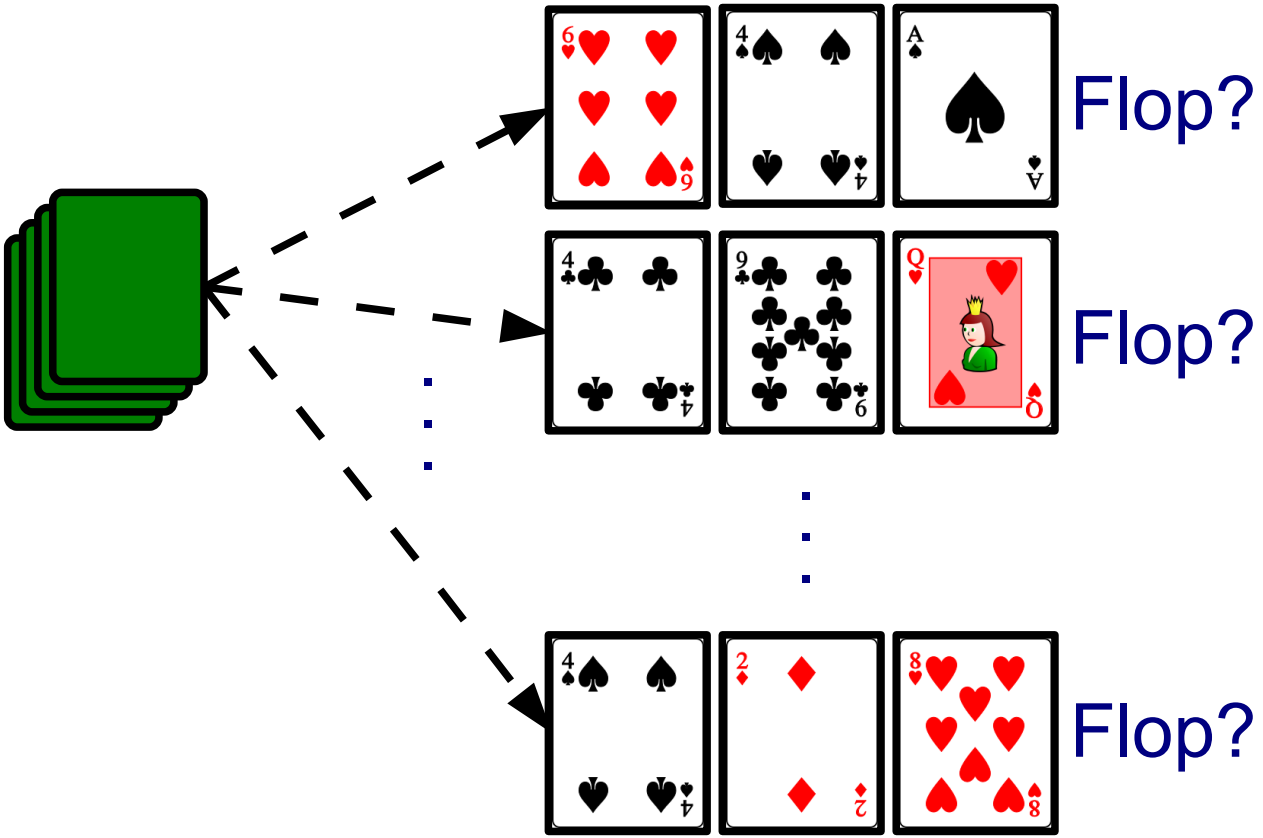


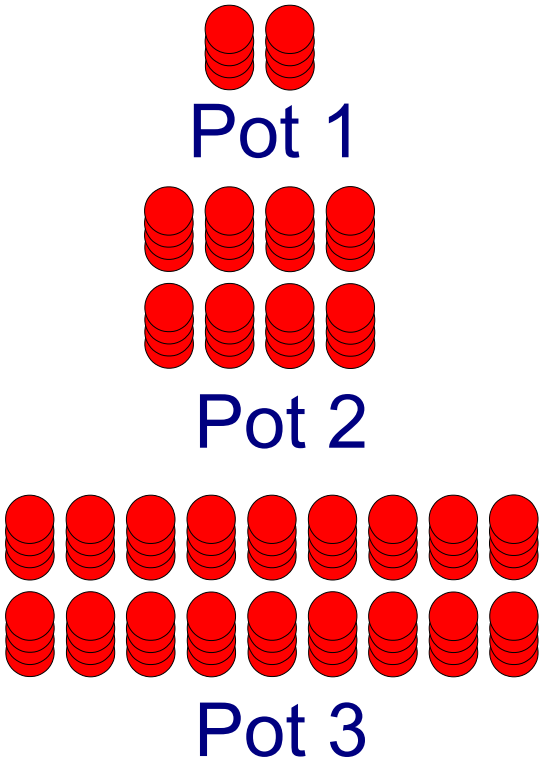
Image sources: Wikipedia



Why Poker Research?

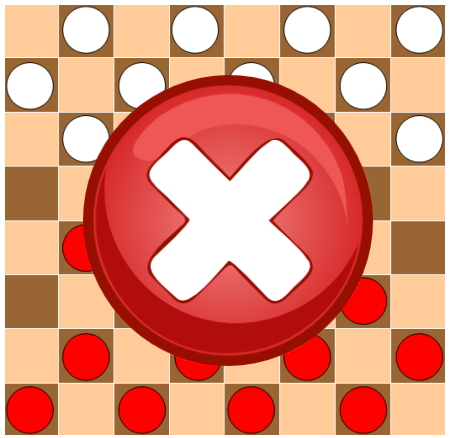
- However, poker is a game with:
  - Stochastic elements
  - Varying outcomes

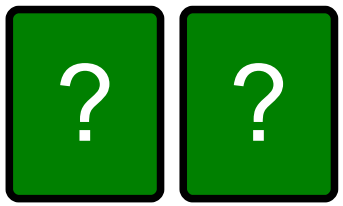
Image source: ebaumsworld.com



Why Poker Research?

- However, poker is a game with:
  - Stochastic elements
  - Varying outcomes
  - Imperfect information





Why Poker Research?

- Poker research is applicable in other areas:
  - Airport security [Pita *et al.*, AI Magazine 2009]
  - Adaptive treatment strategies [Chen and Bowling, NIPS 2012]
  - Sequential auctions [?]

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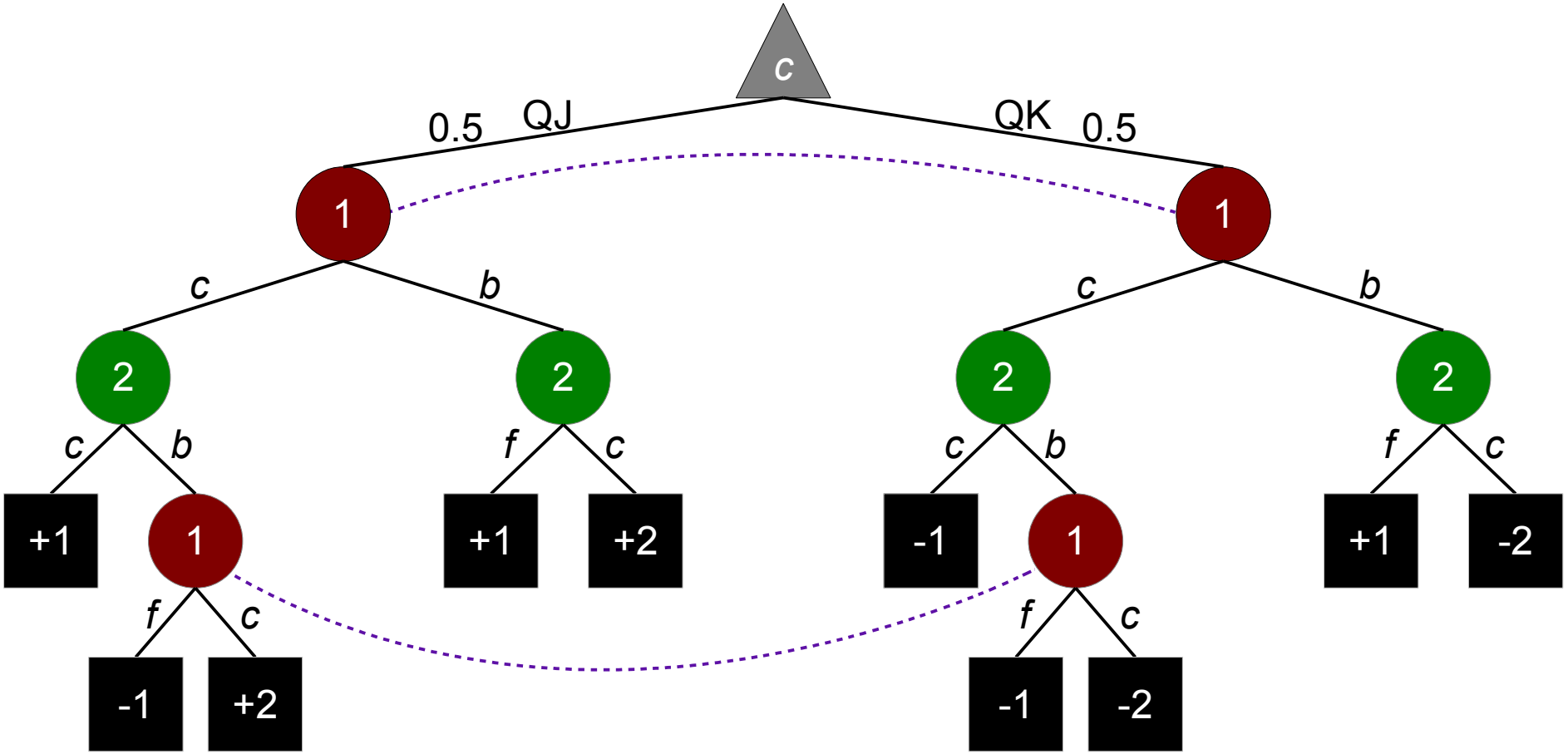
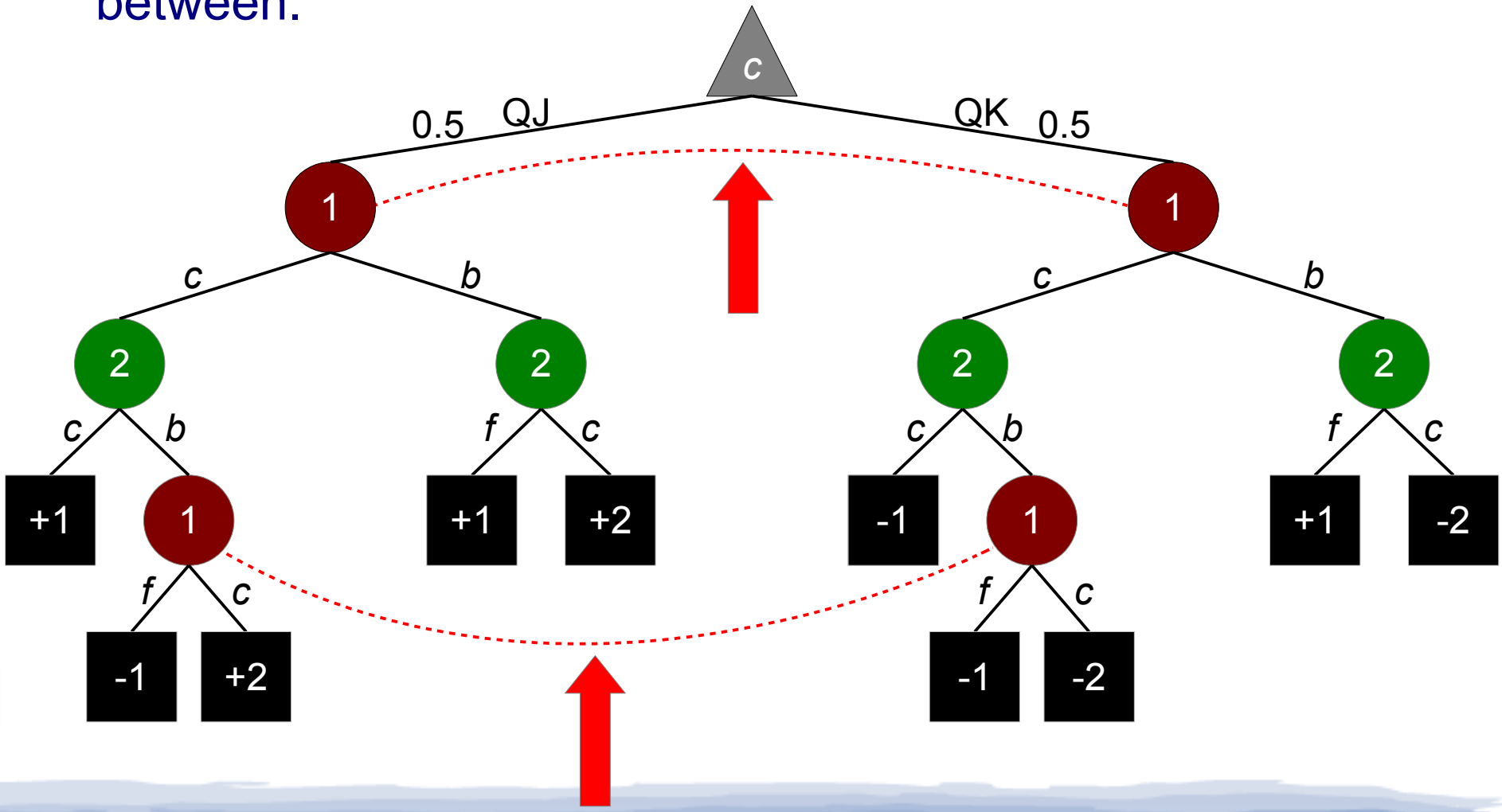
Poker Research Background

- Model poker as an **extensive-form game**:



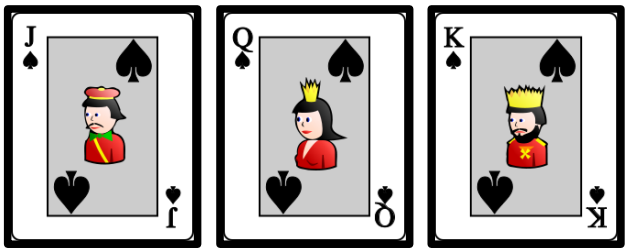
Poker Research Background

- **Information sets**: Sets of states a player cannot distinguish between.



Poker Research Background

- Example: **Kuhn Poker**



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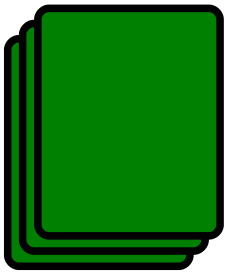
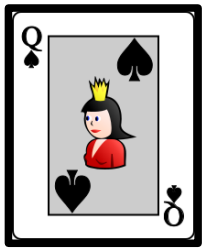


Poker Research Background

- Example: **Kuhn Poker**

?

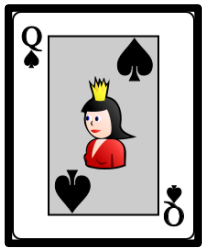


Poker Research Background

- Example: **Kuhn Poker**

Bet!

Fold?
Call?

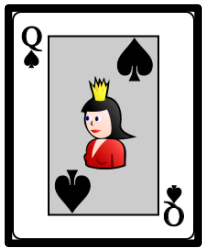


Poker Research Background

- Example: **Kuhn Poker**

?

Call.



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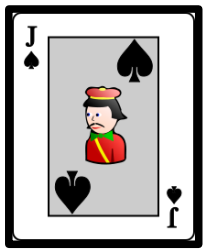
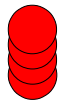
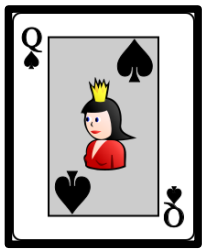


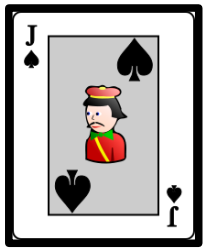




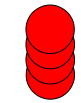
Poker Research Background

- Example: **Kuhn Poker**

-2

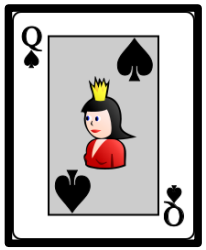


Lose.



+2

Win!



Poker Research Background

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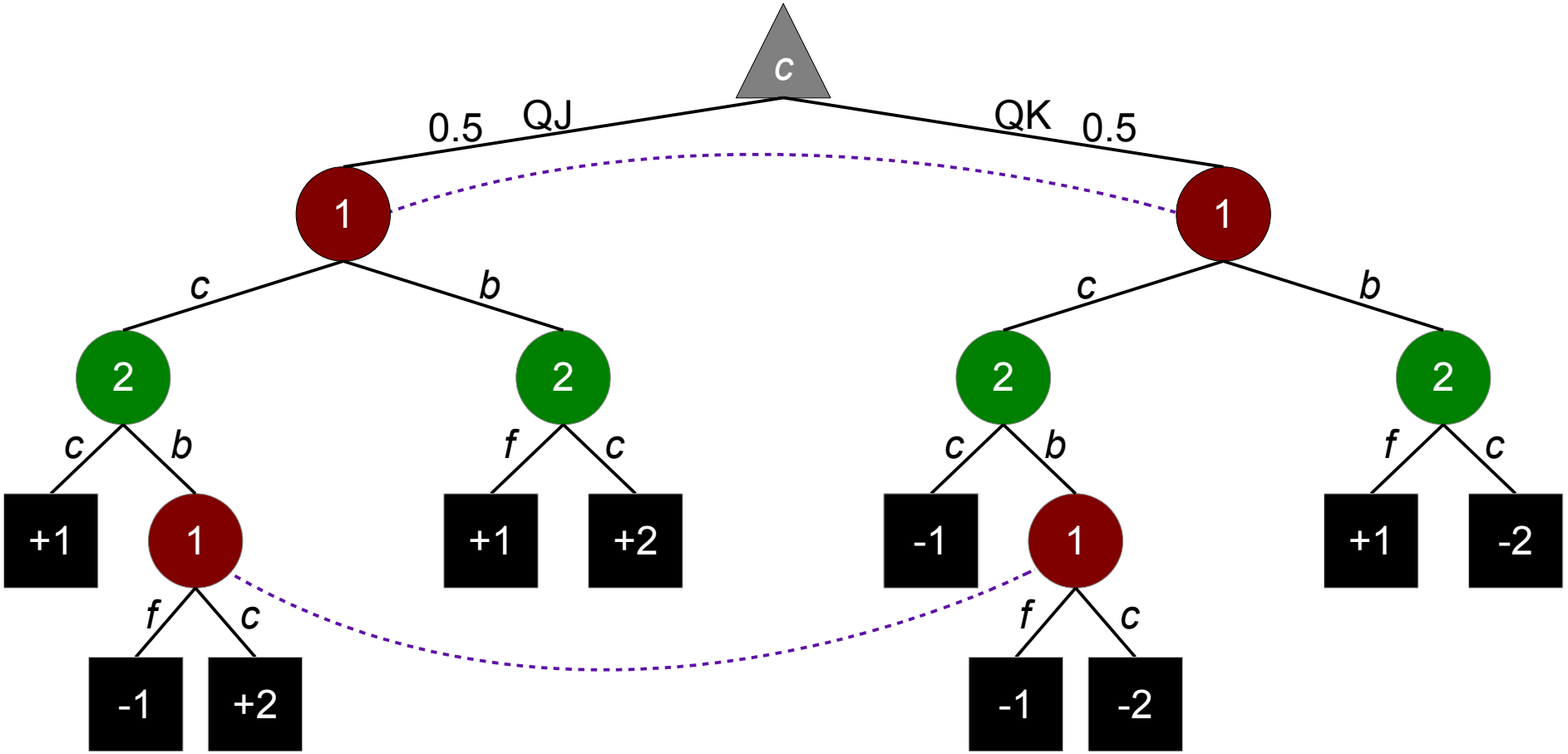

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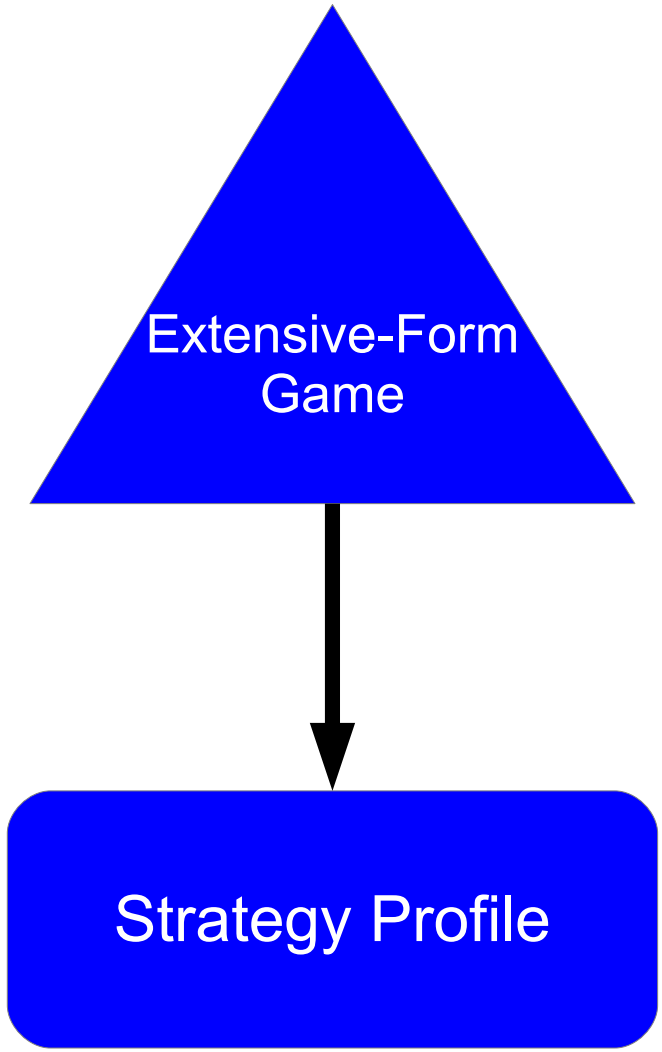
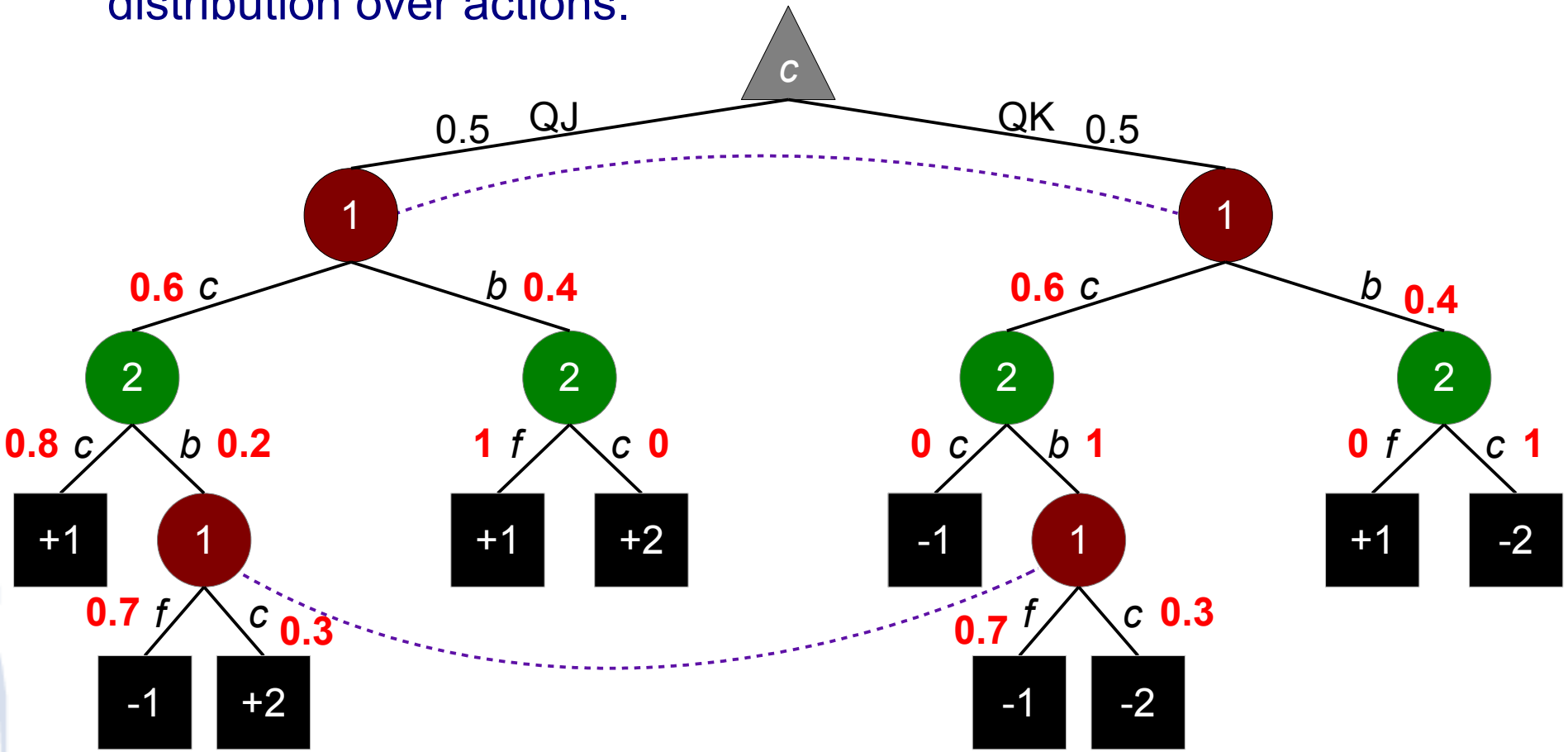


Poker Research Background

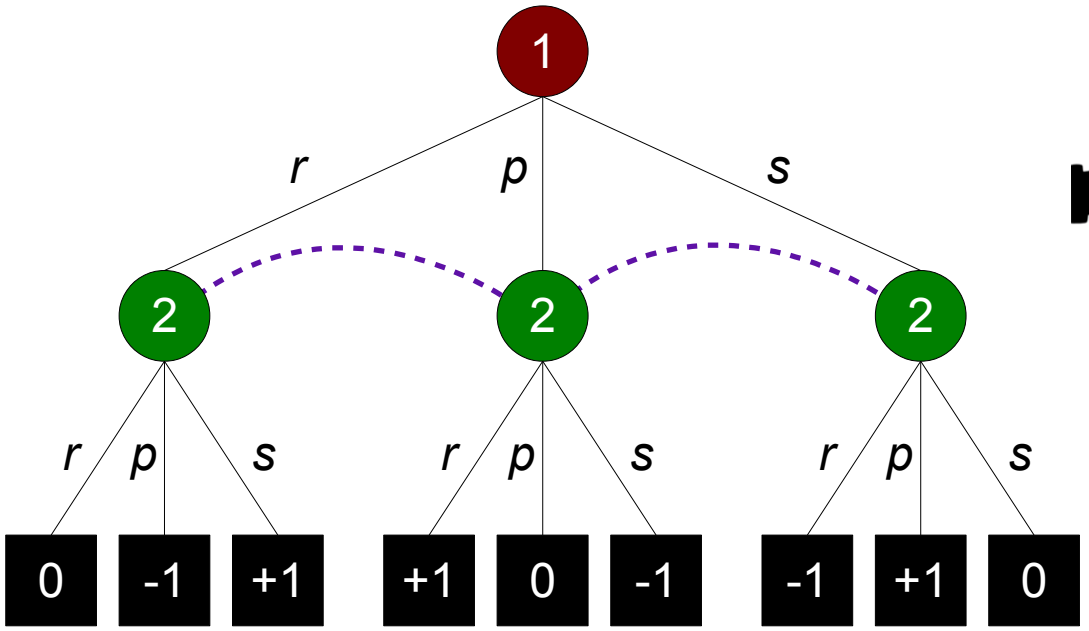
- A **strategy profile** maps each information set to probability a distribution over actions.



Poker Research Background

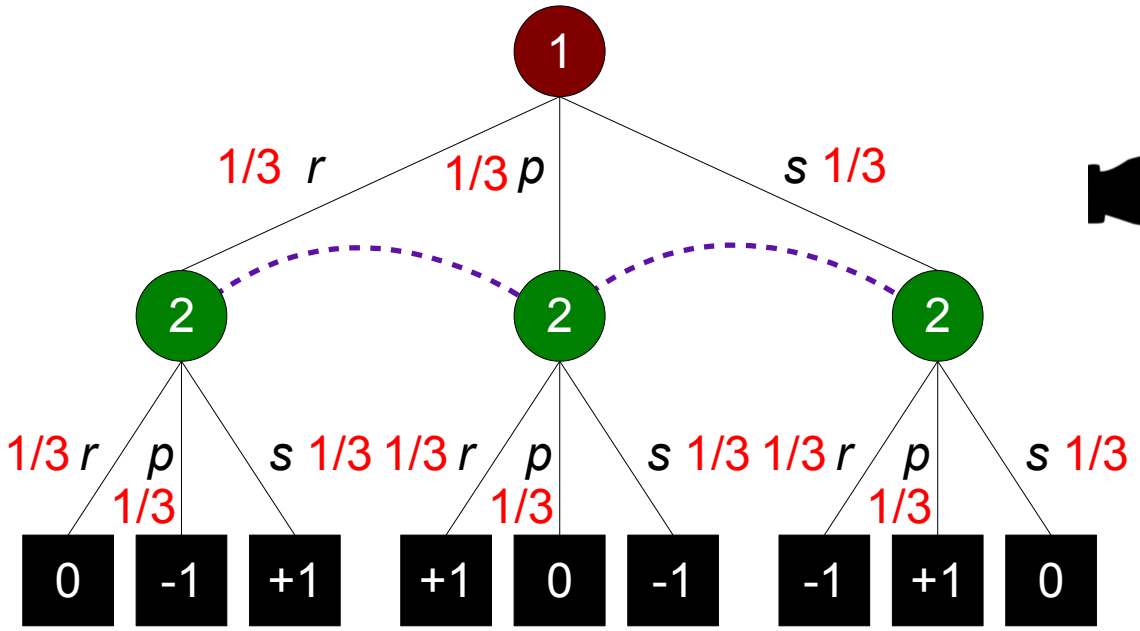
- What type of strategy profile do we want?
  - Nash equilibrium
- Example: Rock-Paper-Scissors

Poker Research Background



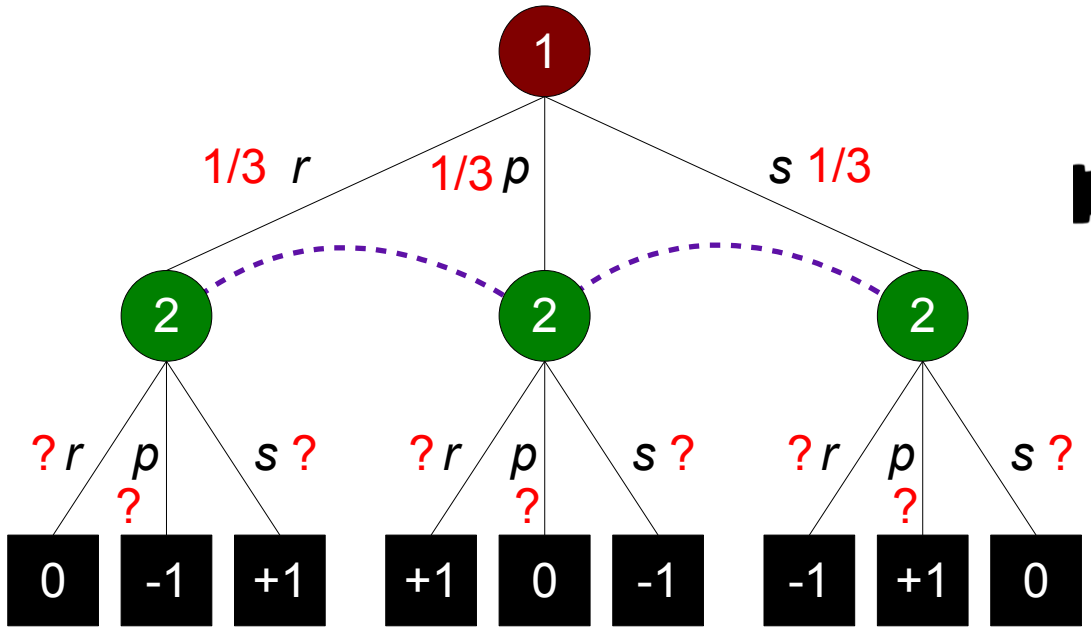
Poker Research Background

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



Poker Research Background

- A Nash equilibrium in a 2-player game is a defensive strategy:
  - “I can't lose no matter what my opponent does.”



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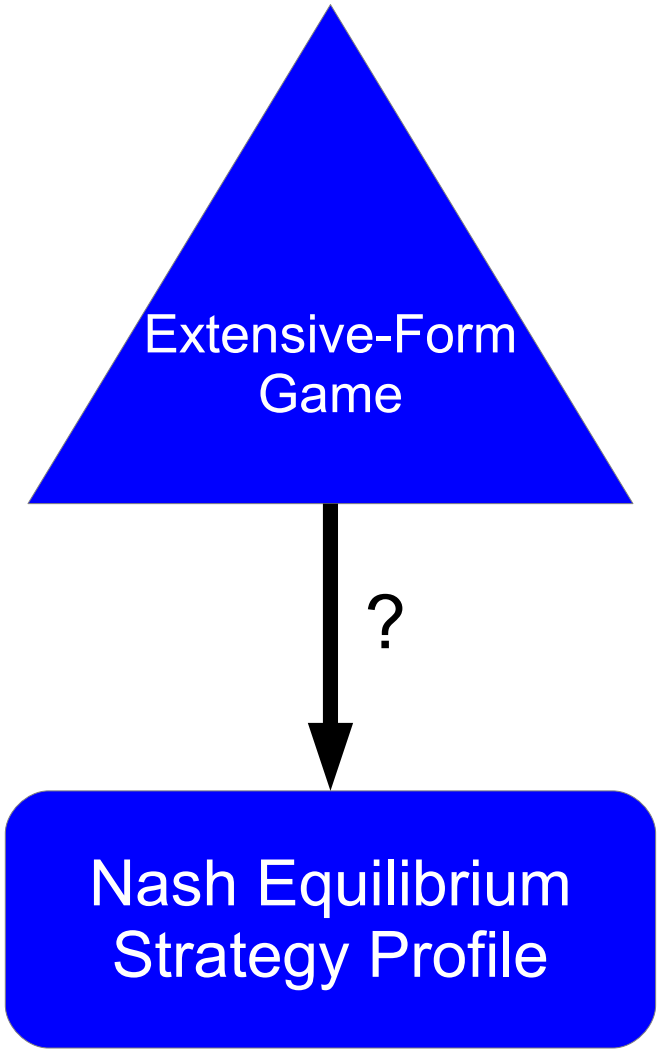
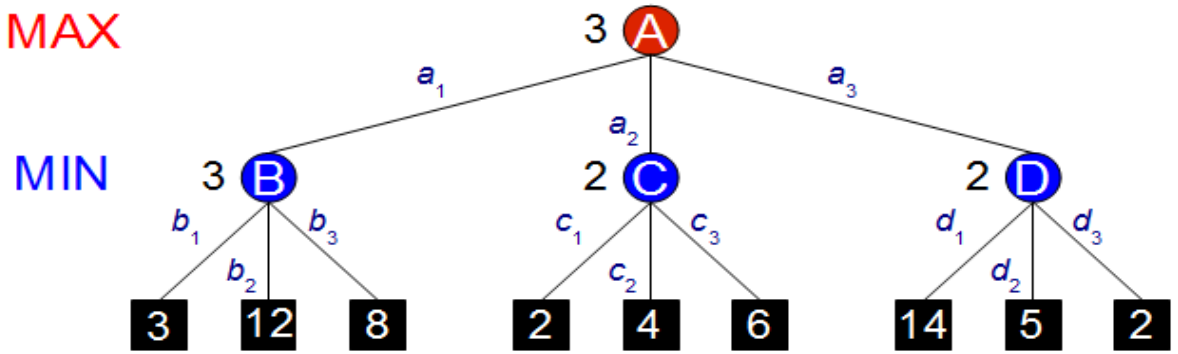
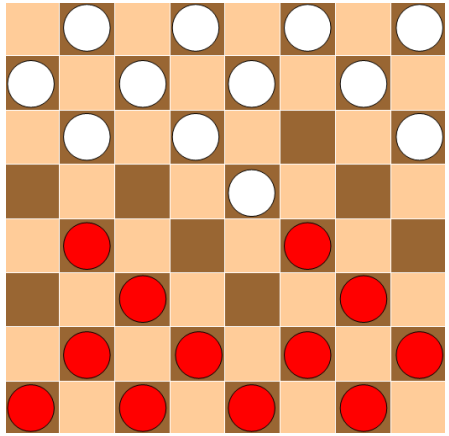


Poker Research Background

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





Source: clker.com

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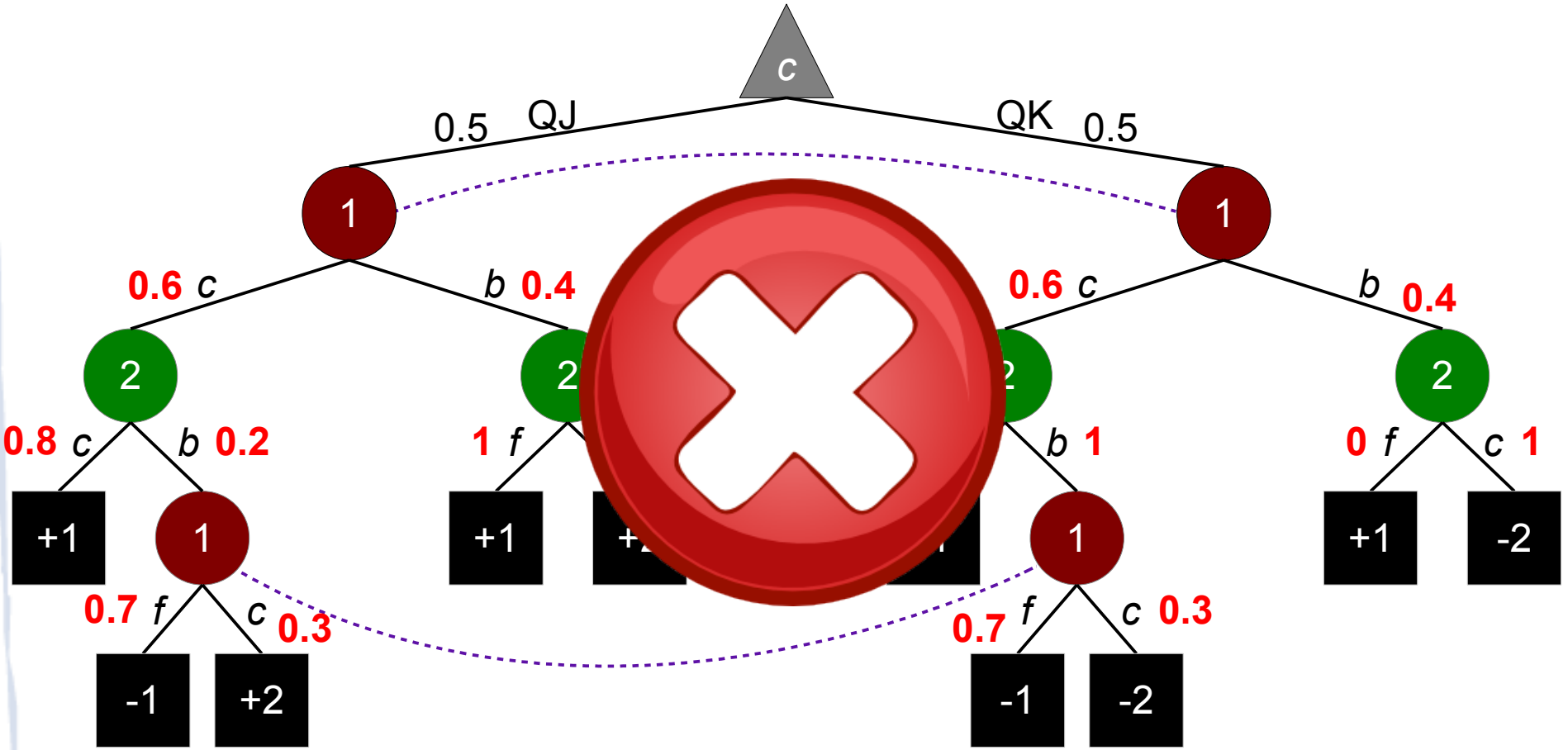
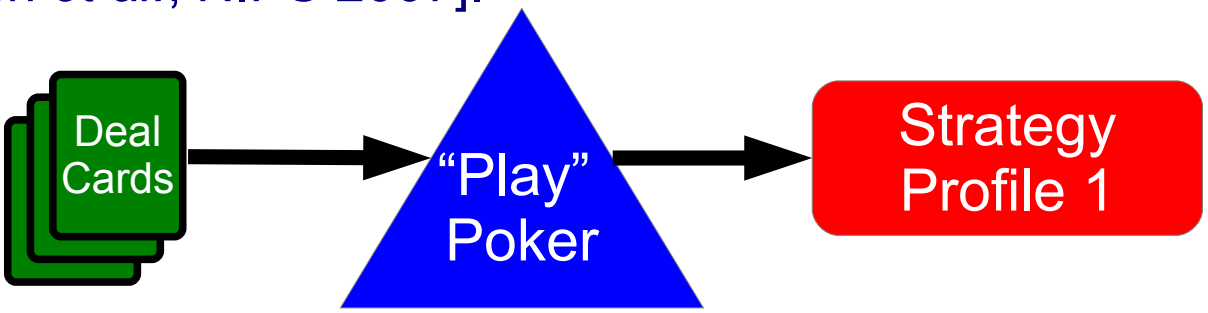


Poker Research Background

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



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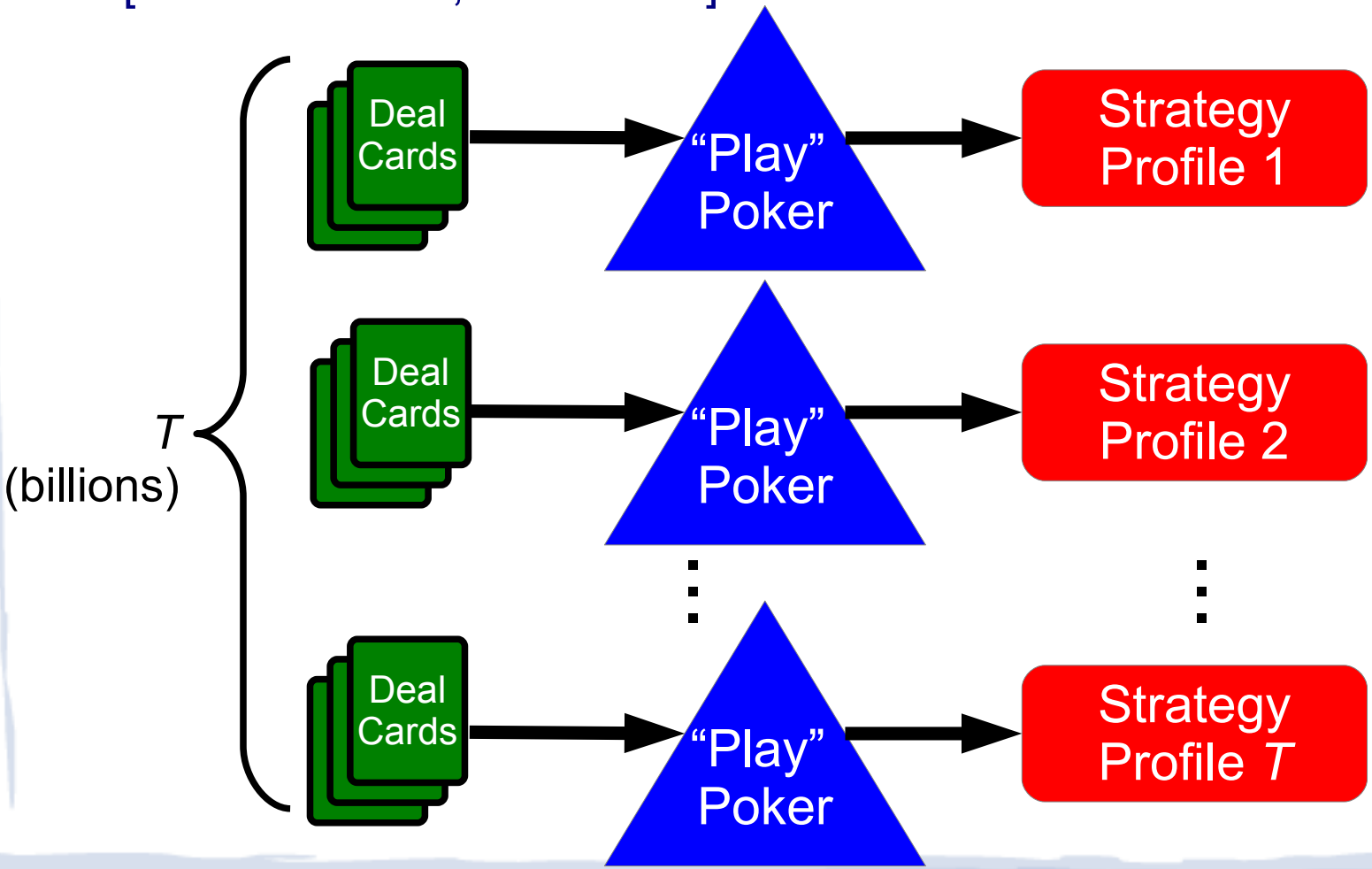

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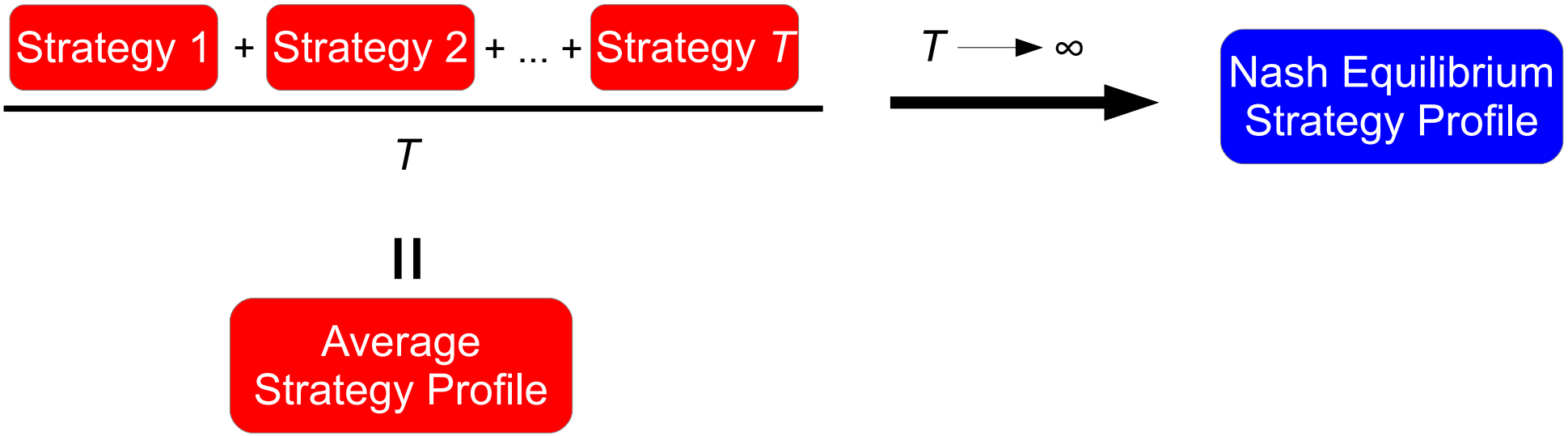

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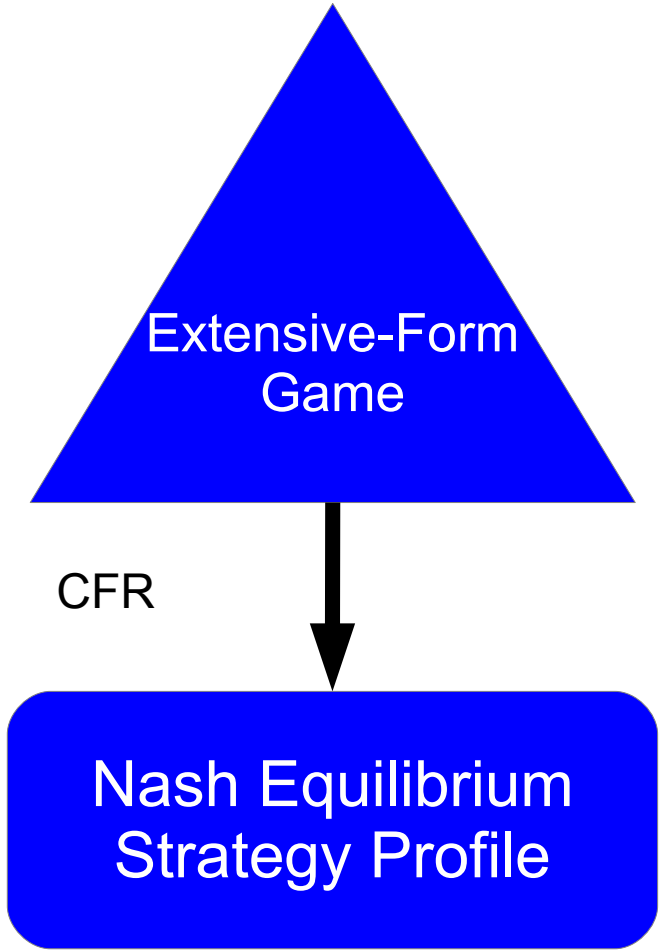
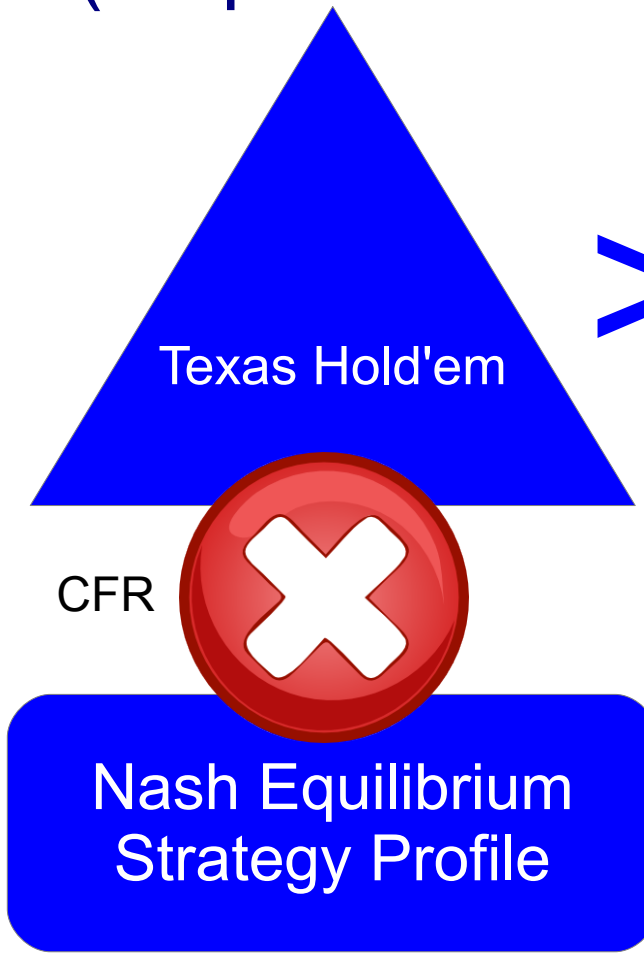


Poker Research Background

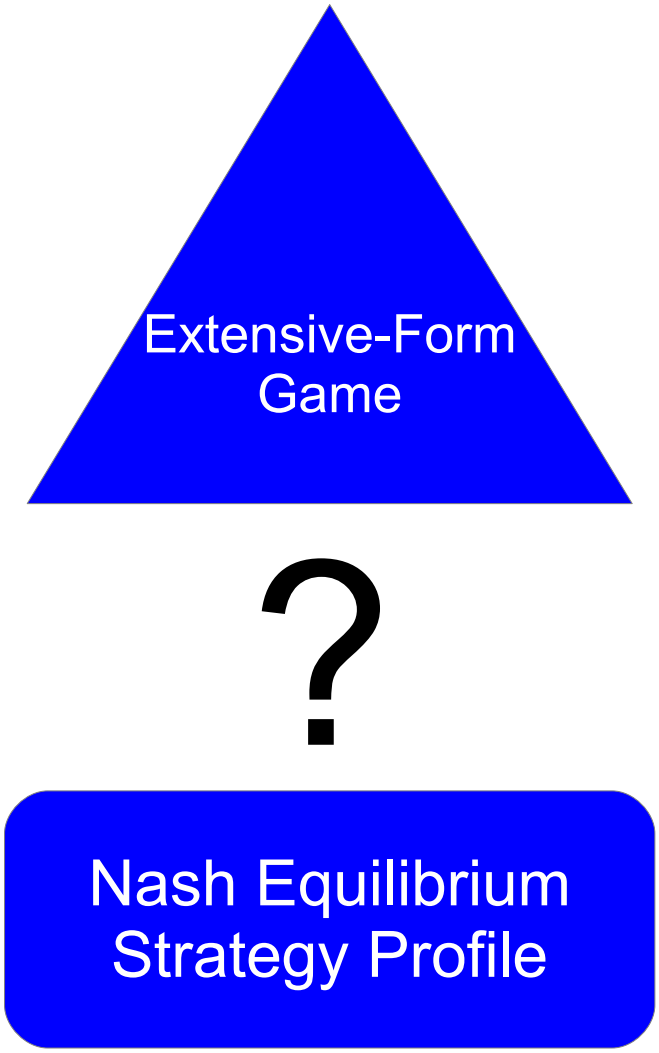
- Huge problem (no pun intended):



$>10^{14}$

> 5 million GB

Poker Research Background



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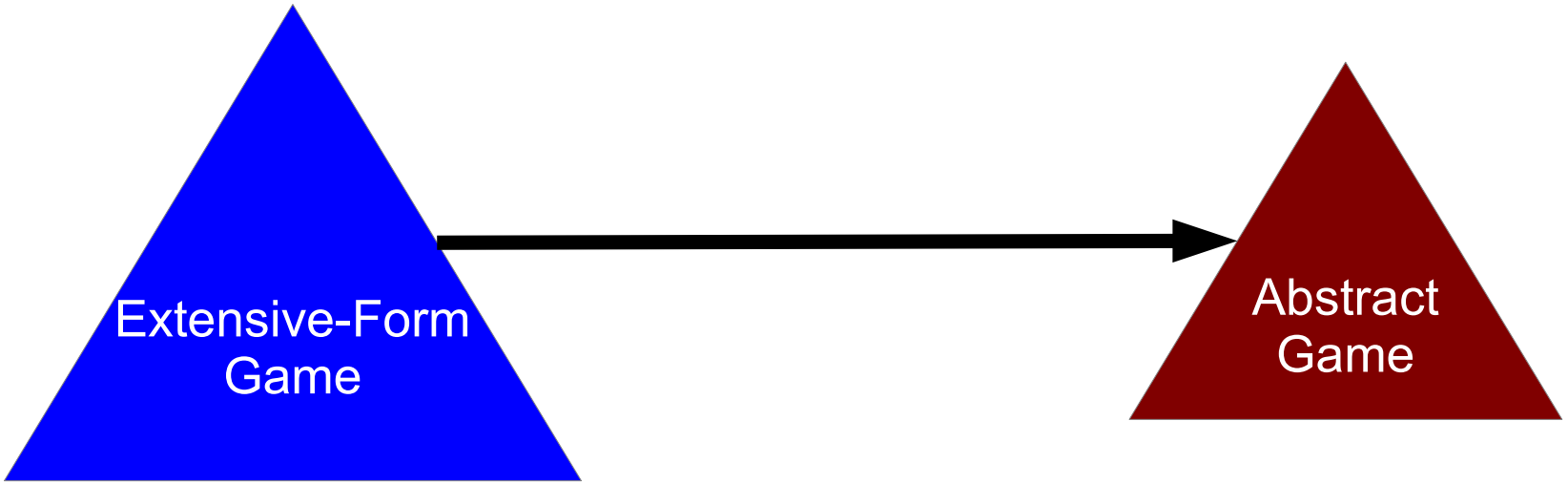
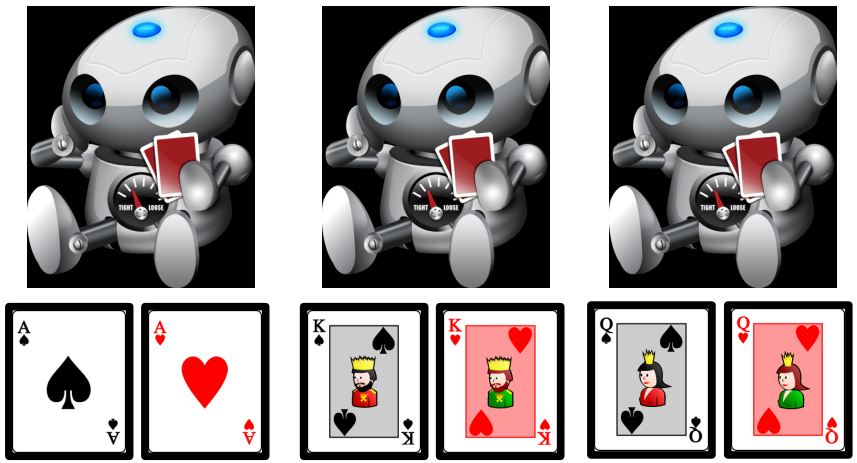
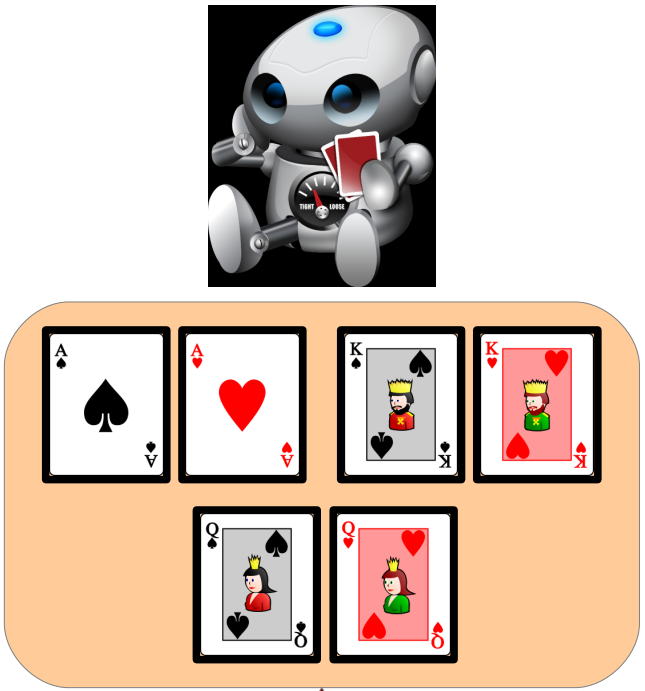


Poker Research Background

- Merge card deals into buckets.



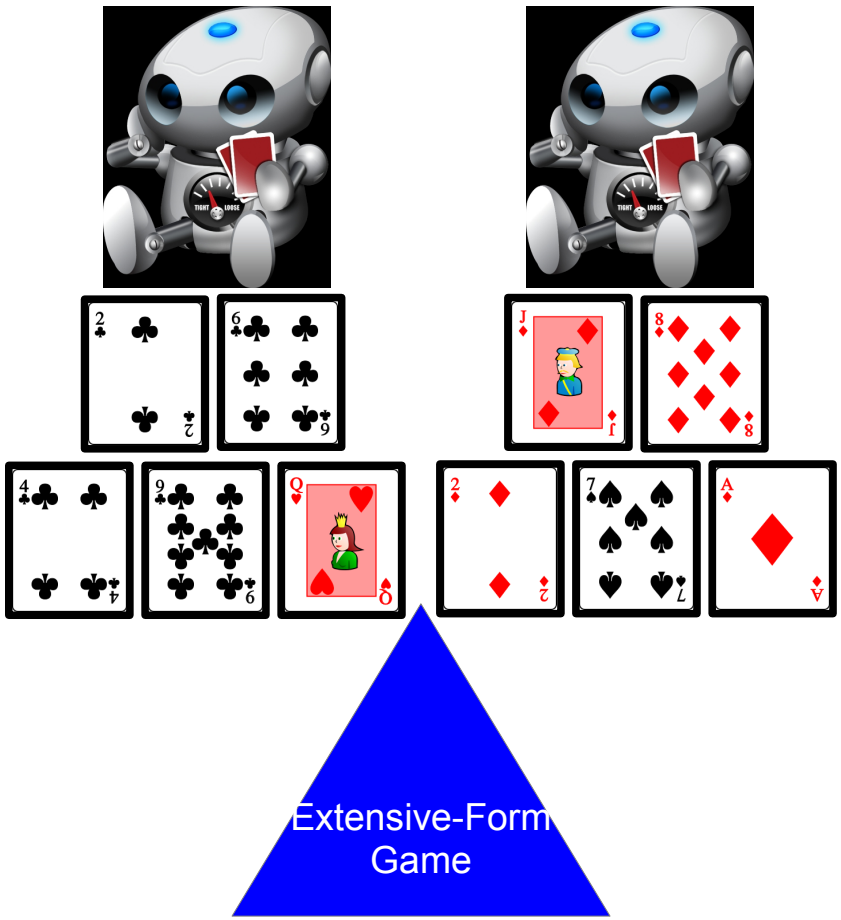
Extensive-Form Game

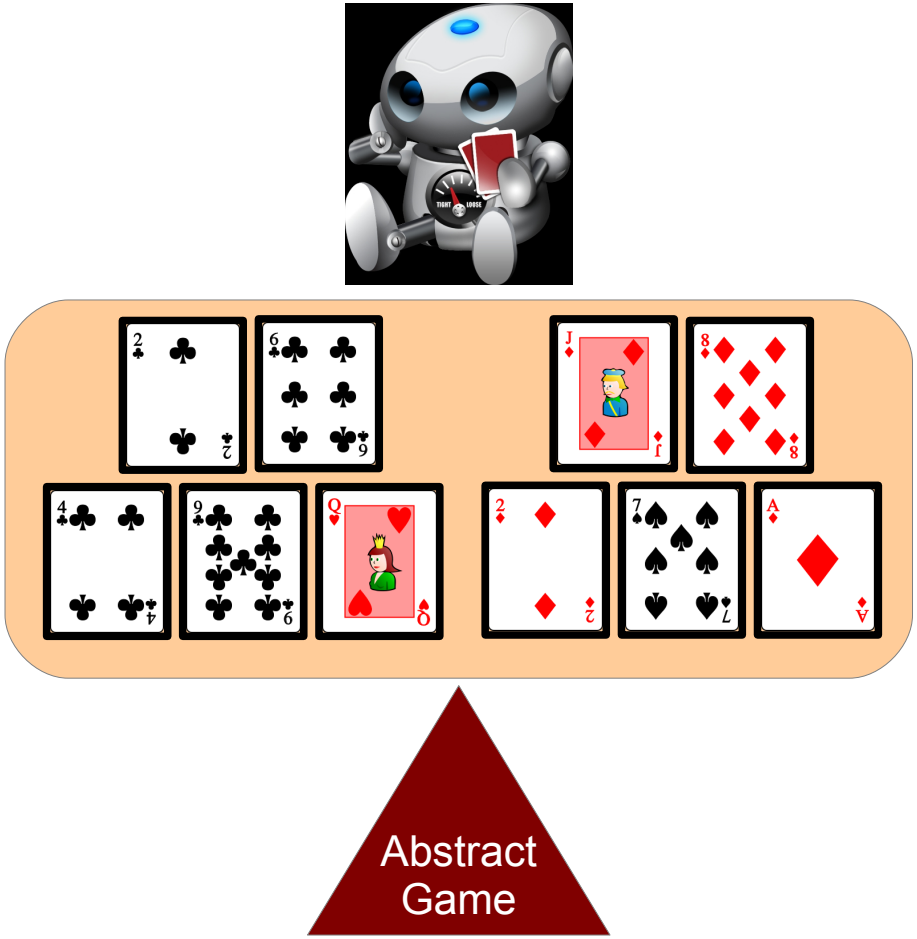


Abstract Game

Poker Research Background

- Merge card deals into buckets.





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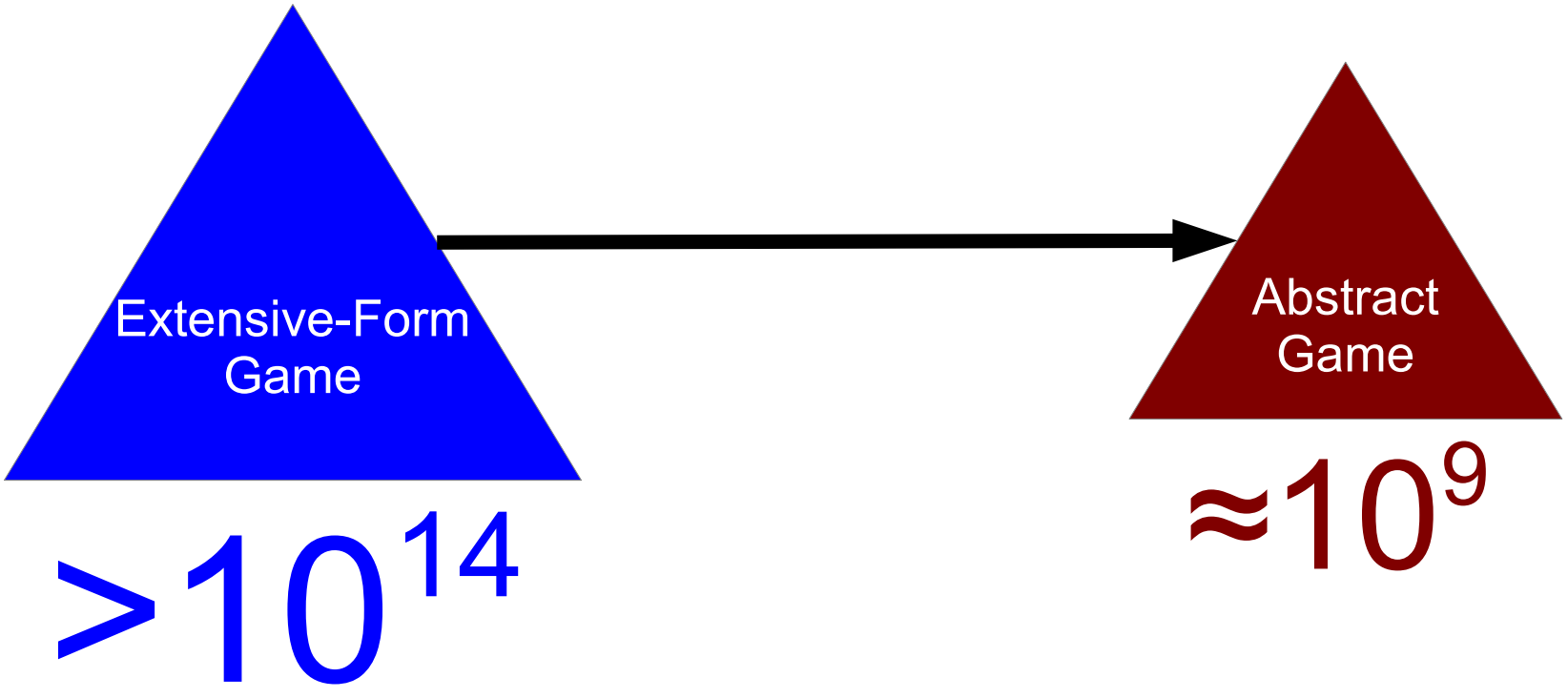

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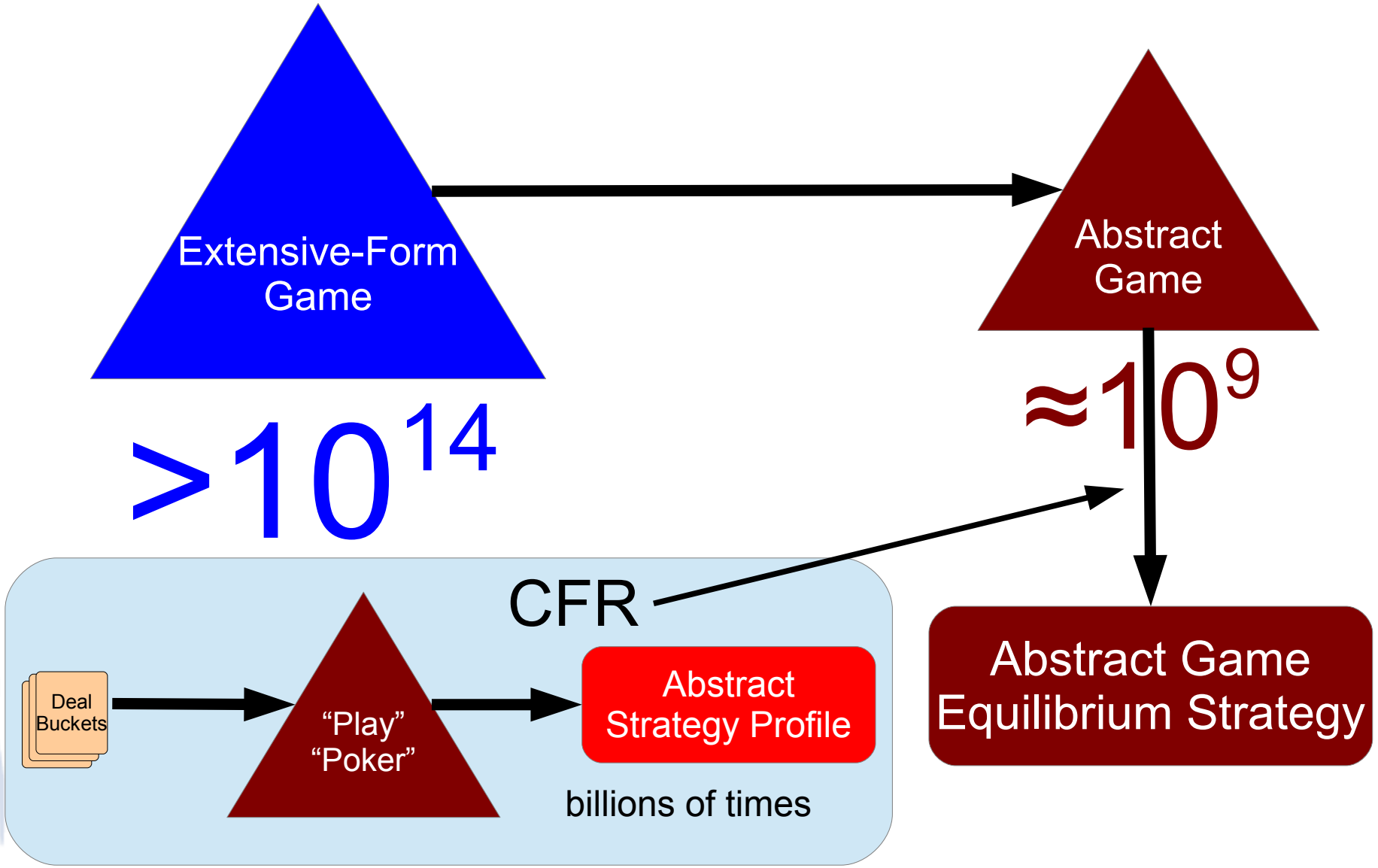

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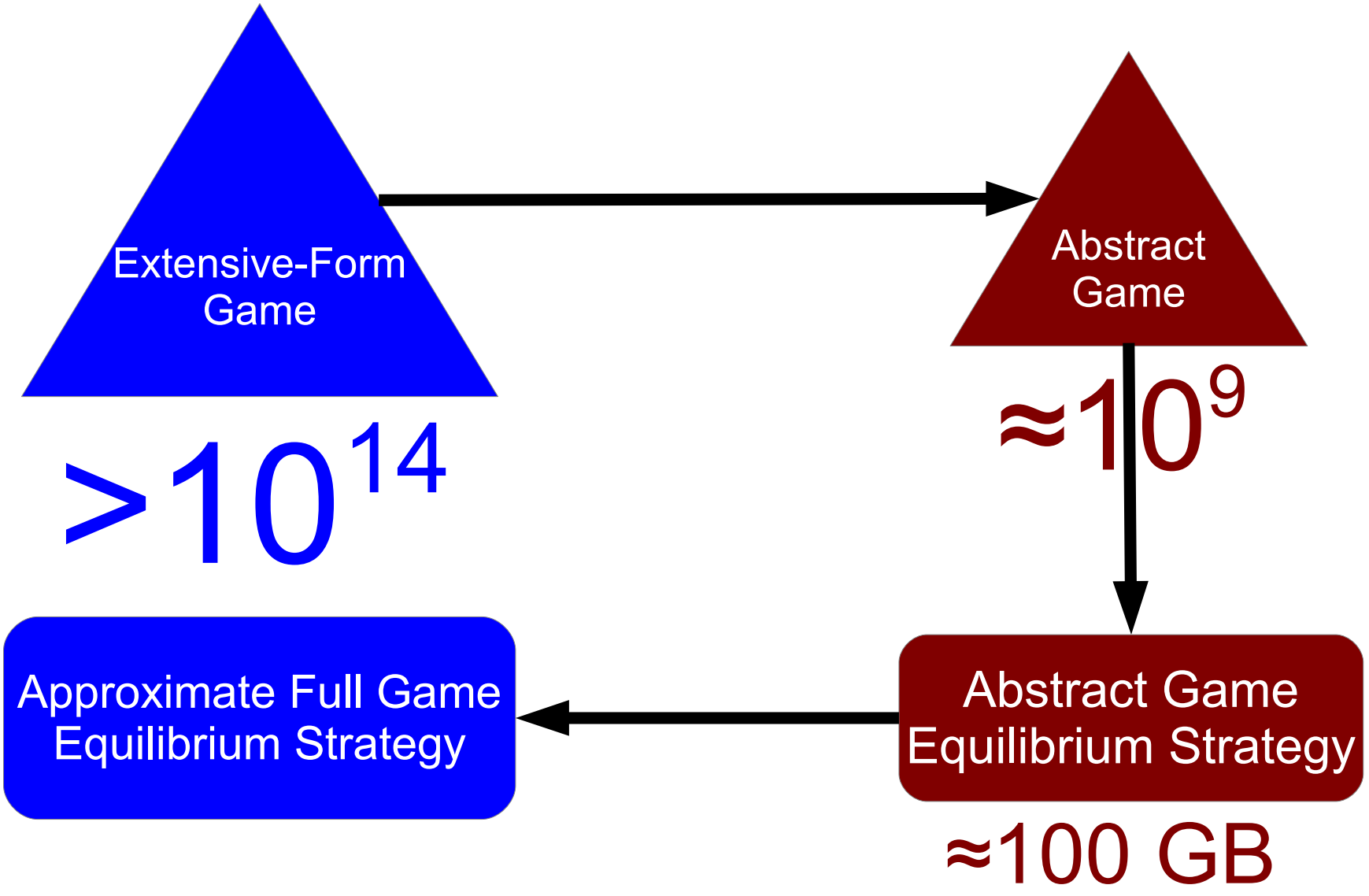

Outline of Presentation

- Computer Poker Primer
  - Motivation
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- **New Contributions to Computer Poker**
  - **Research + Hyperborean3p**
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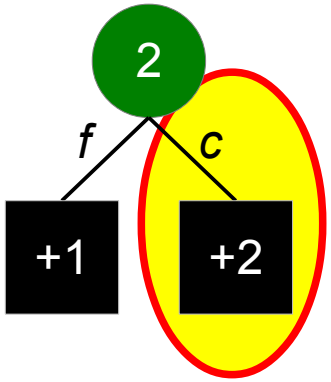
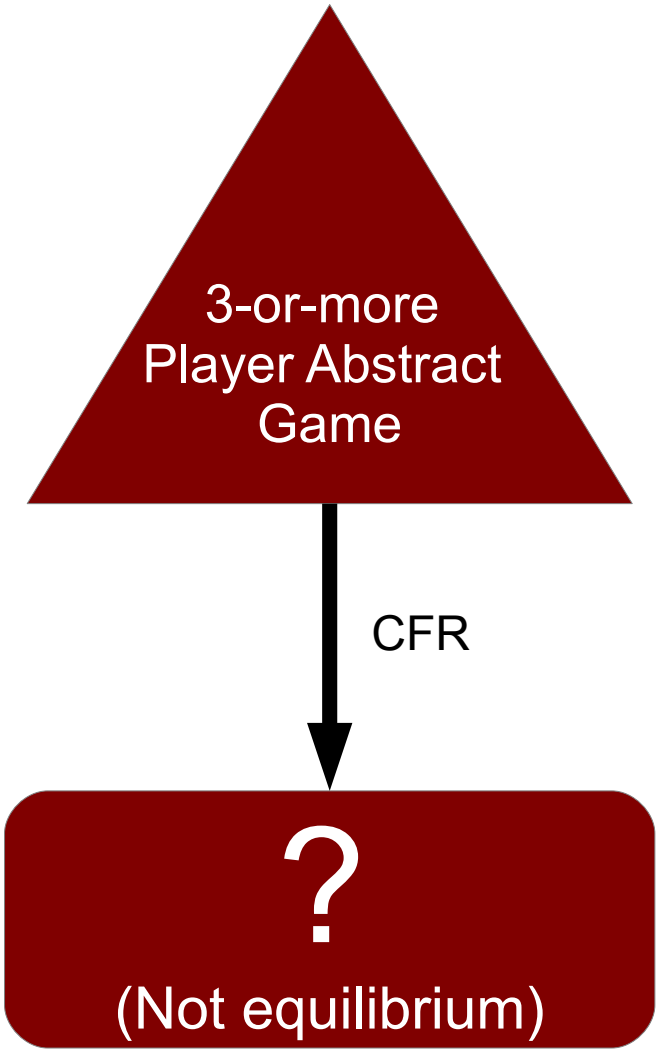
  - StarCraft, ALE, automated content generation
- Teaching Interests
  - Game design, AI in video games

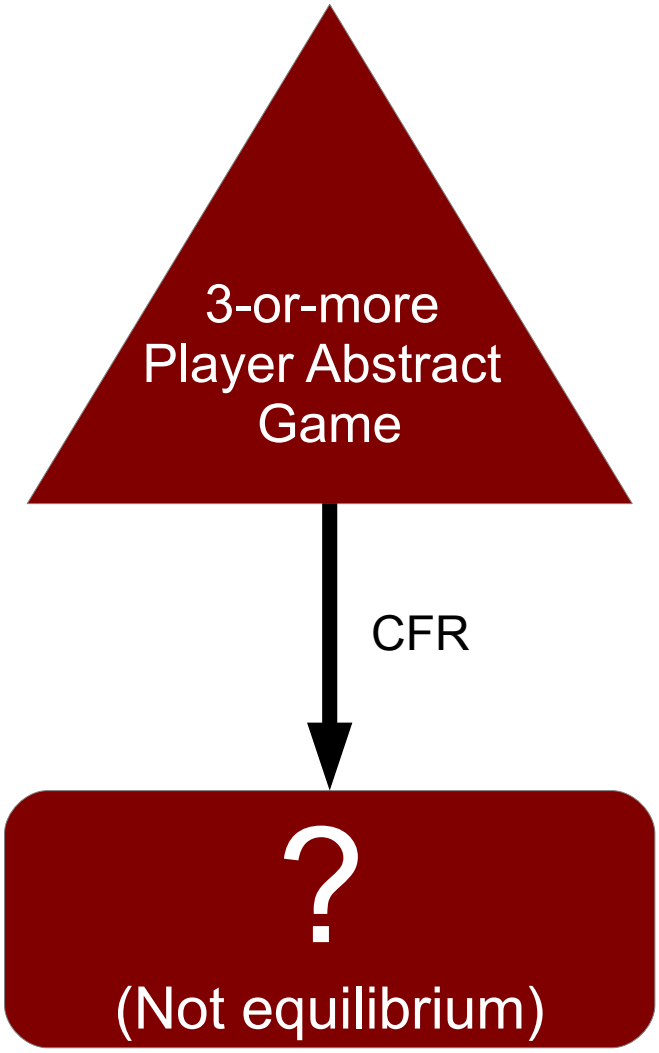


Contribution 1: Domination

Domination



Domination



Annual Computer Poker Competition
3-Player Limit Texas Hold'em - 2009

Agent	Total Bankroll (mbb/g)
Hyperborean3p	319 ± 2
dpp	171 ± 2
akuma	151 ± 2
CMURingLimit	-37 ± 2
dcu3pl	-63 ± 2
Bluechip	-548 ± 2

University of Alberta

DCU

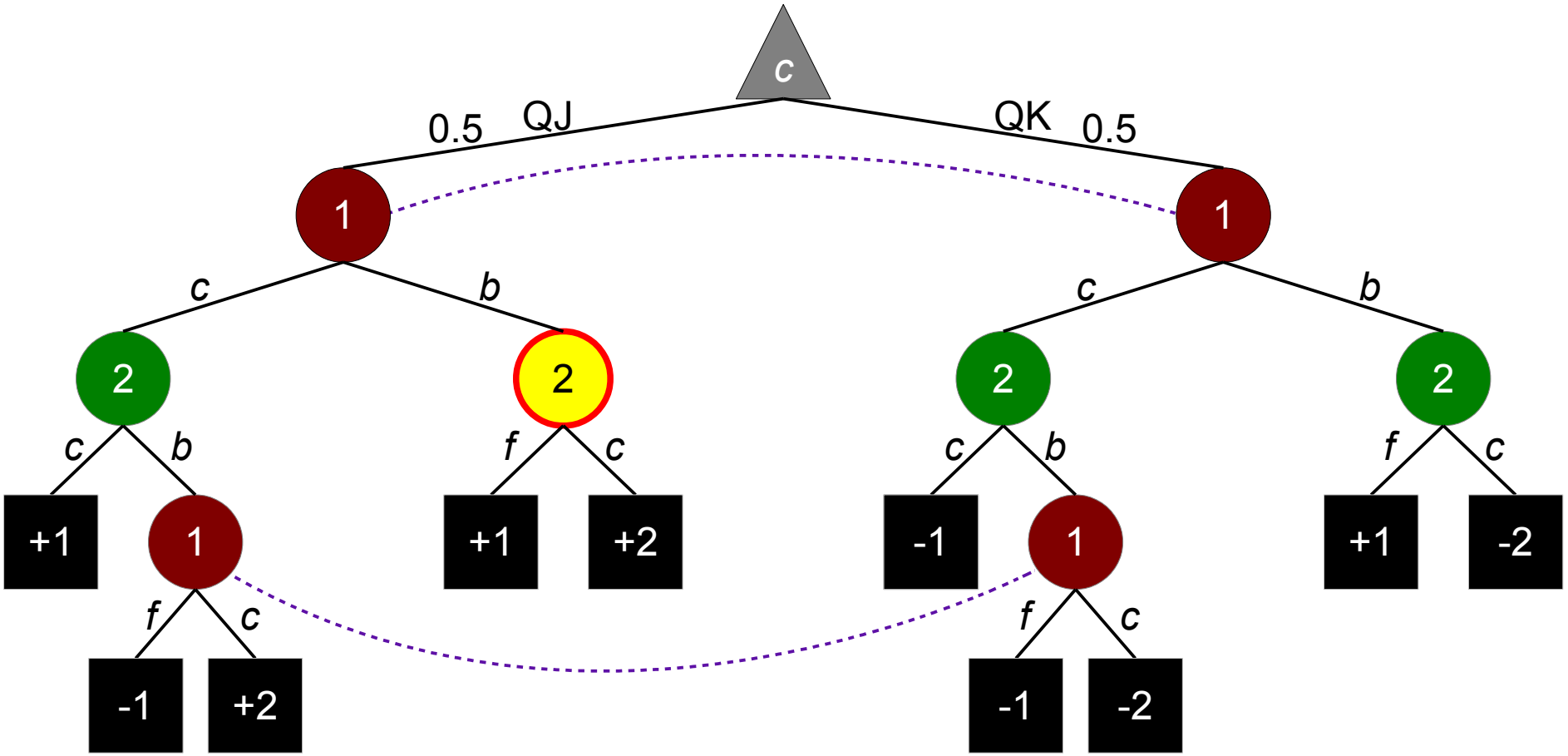
Carnegie Mellon University

University of Minnesota
Driven to Discover℠

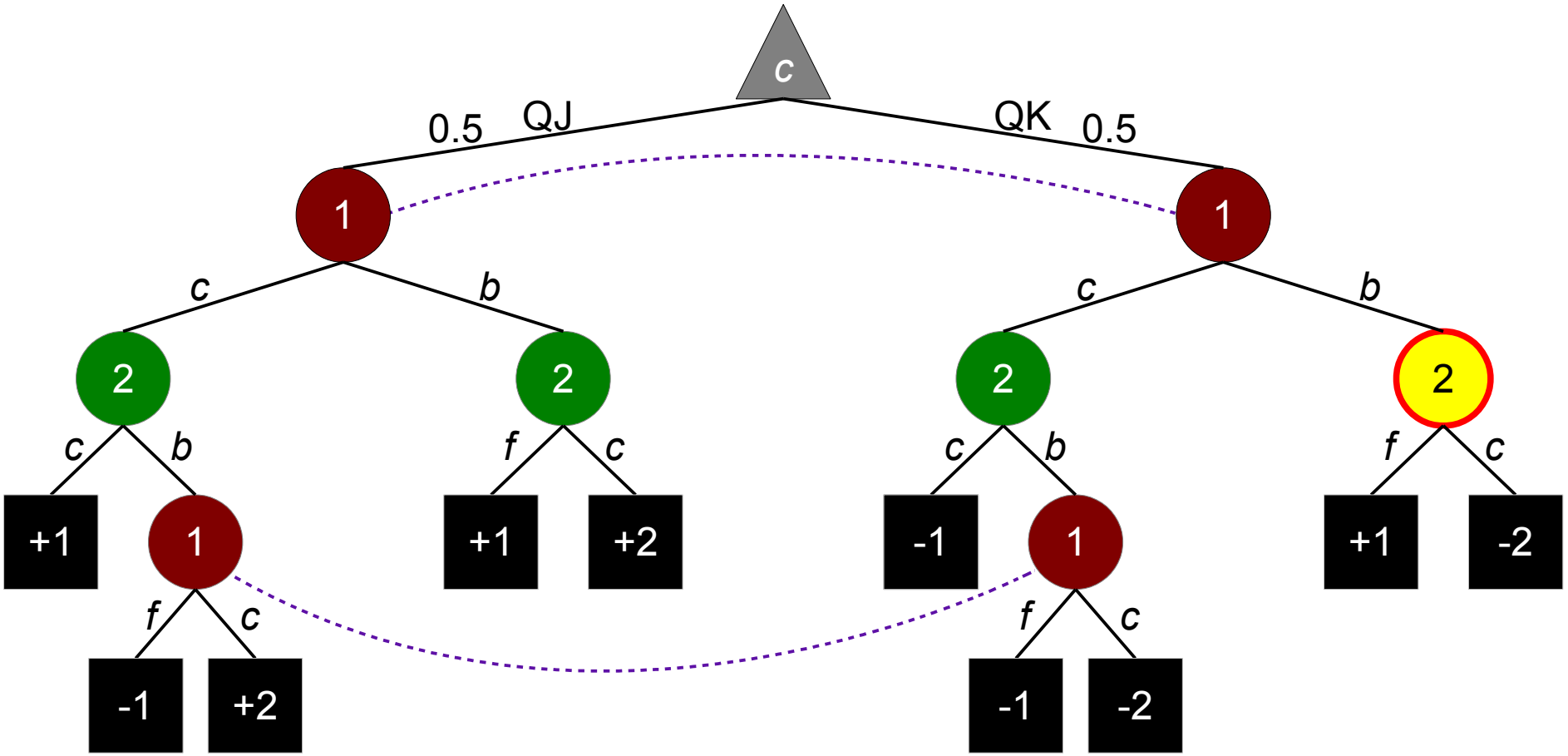
Technische Universität Darmstadt

The University of Auckland
New Zealand
Te Whare Wānanga o Tāmaki Makaurau

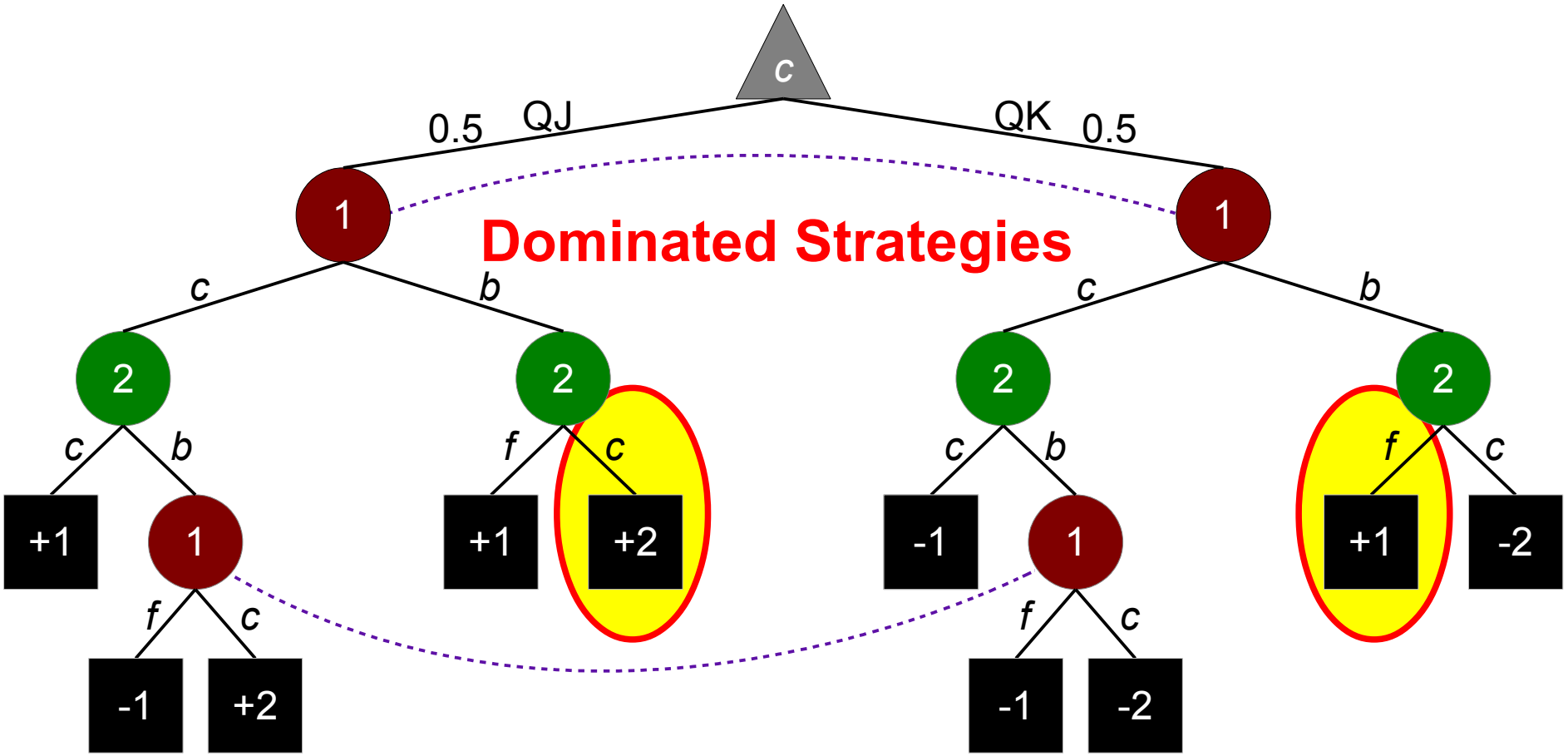
Domination



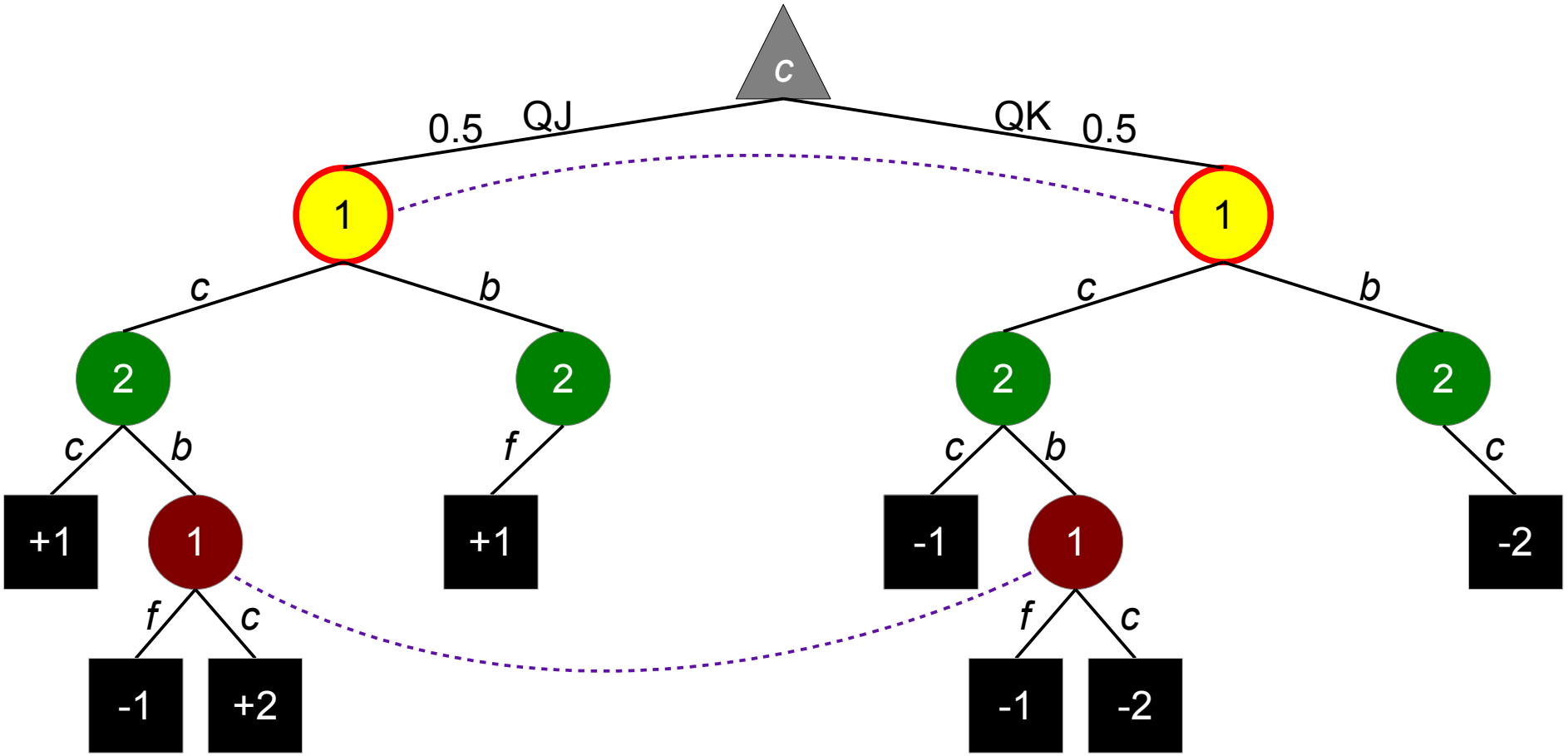
Domination



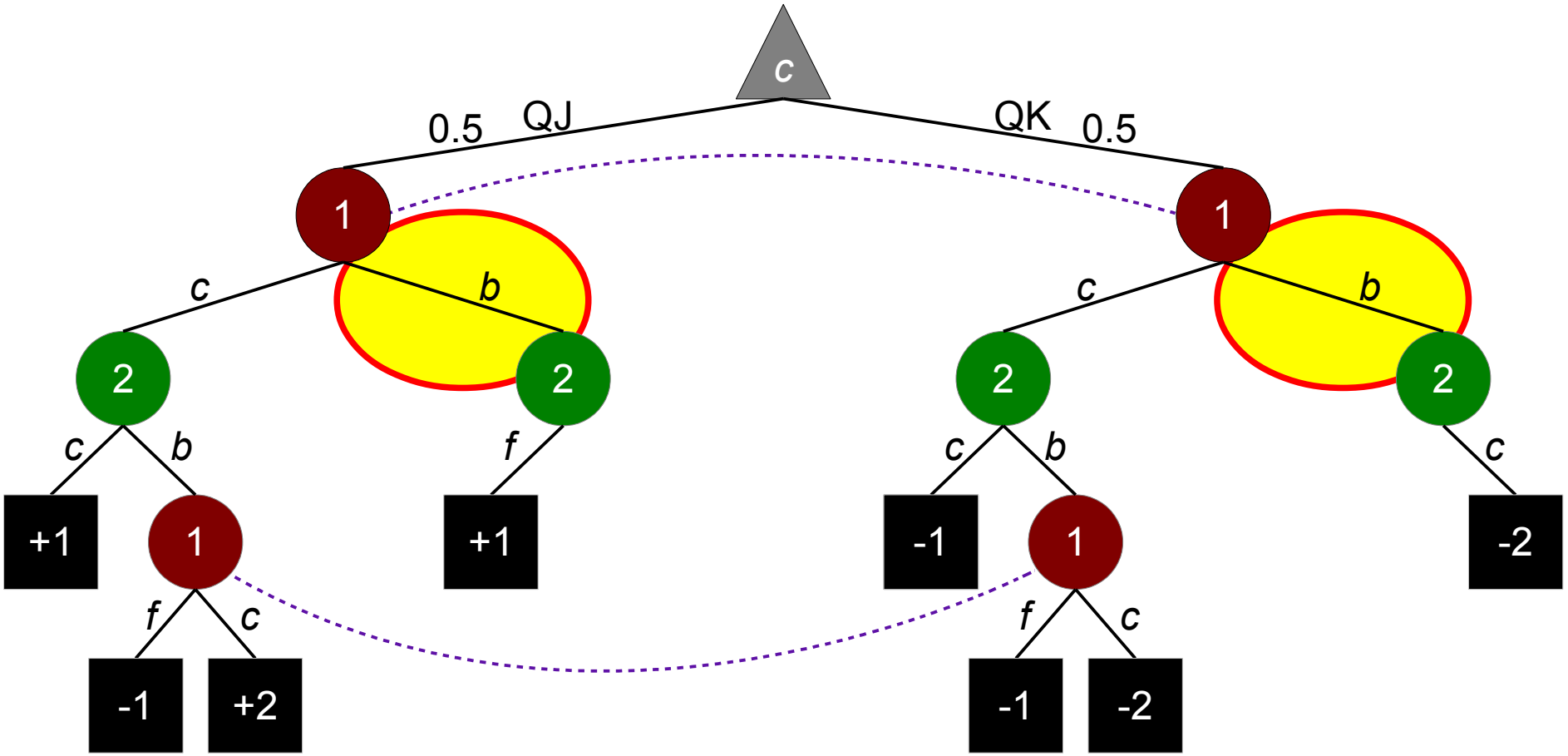
Domination


c
0.5
QJ
QK
0.5
1
1
Dominated Strategies
c
b
c
b
2
2
2
2
c
b
f
c
c
b
f
c
+1
1
+1
+2
-1
1
+1
-2
f
c
f
c
-1
+2
-1
-2

Domination

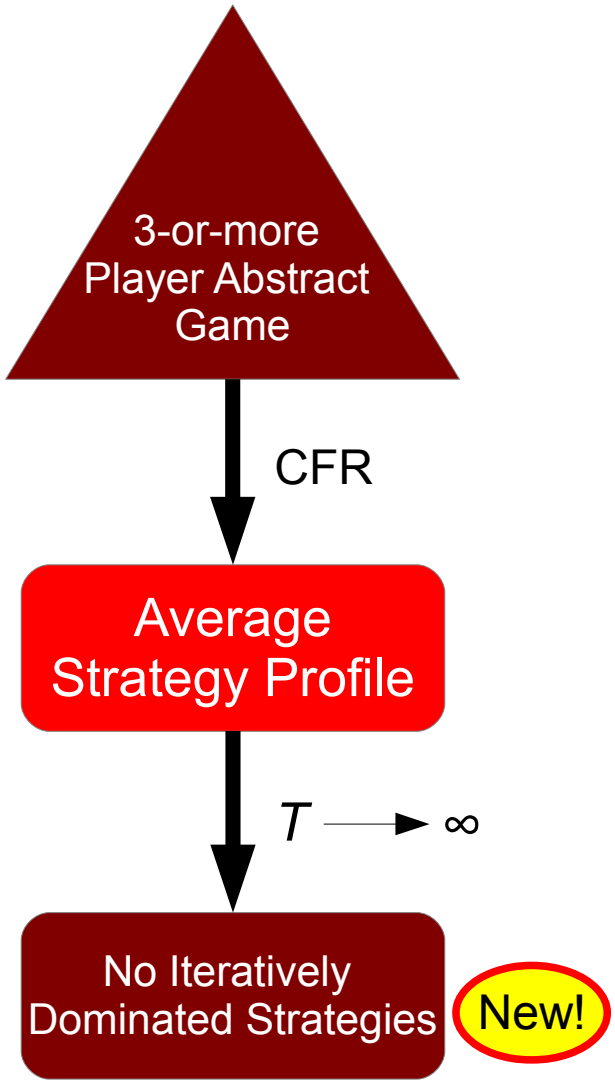


Domination



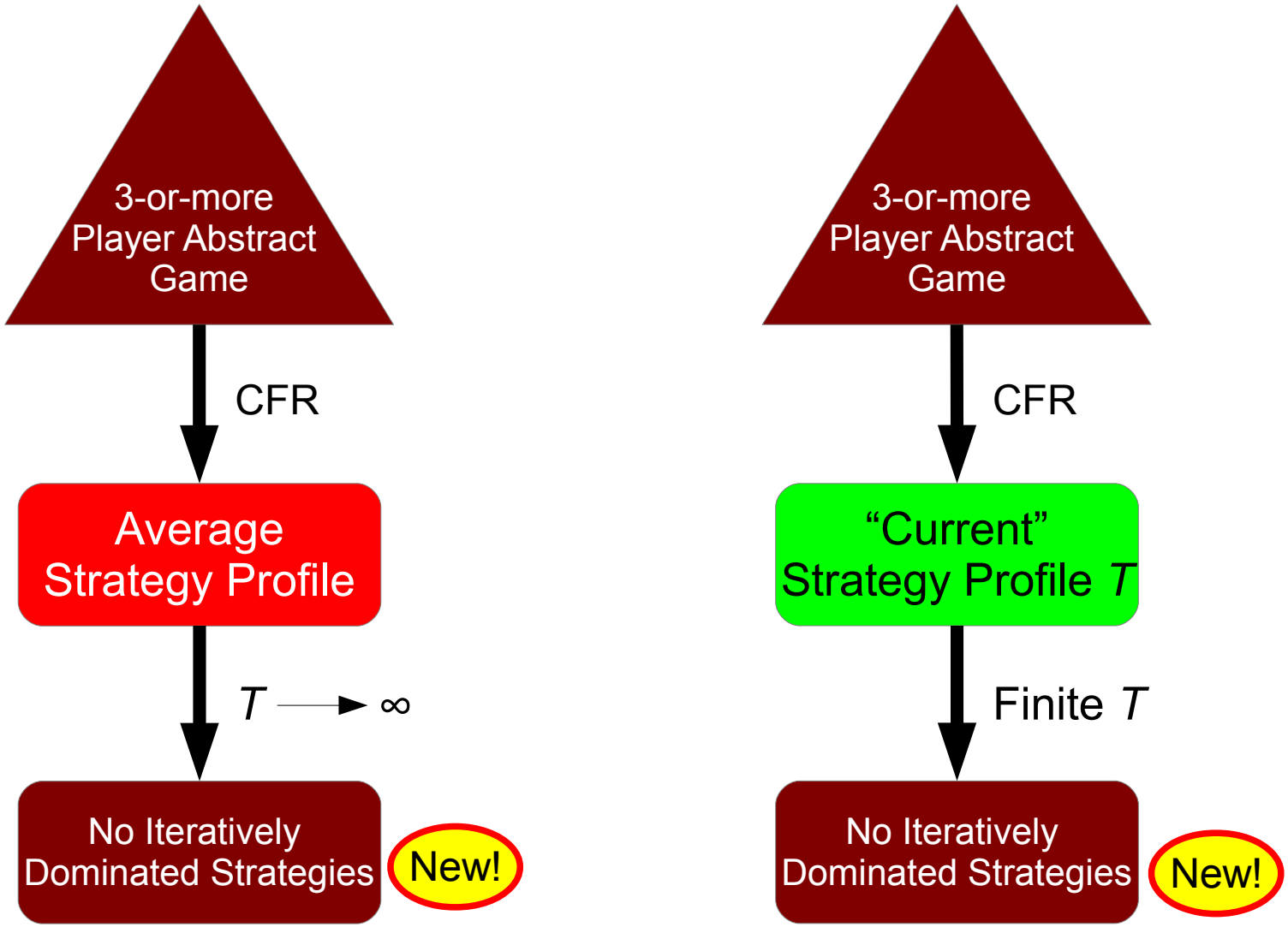
Iteratively Dominated Strategy

Domination



[G., submitted to EC 2013]

Domination



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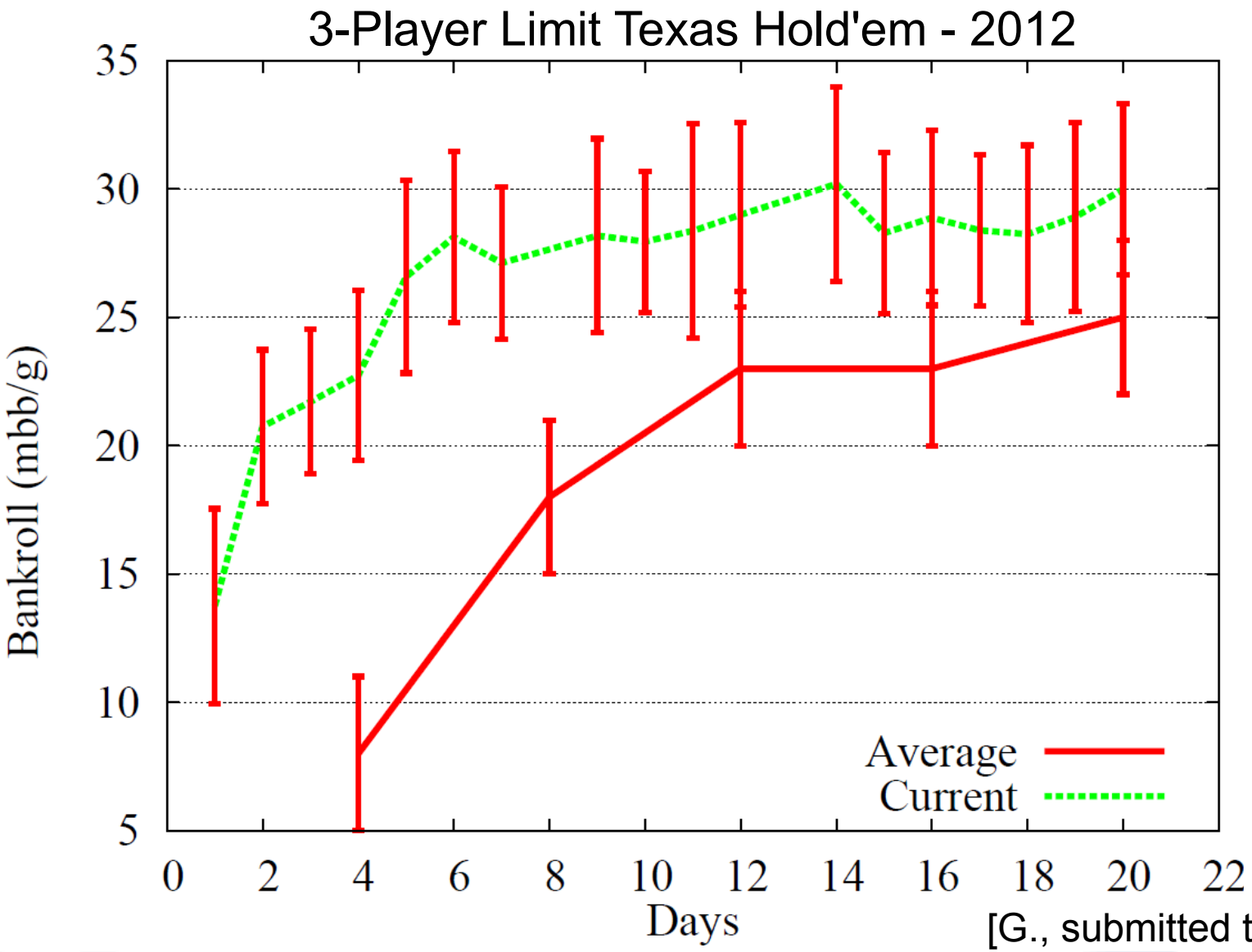

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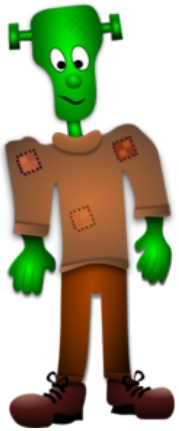
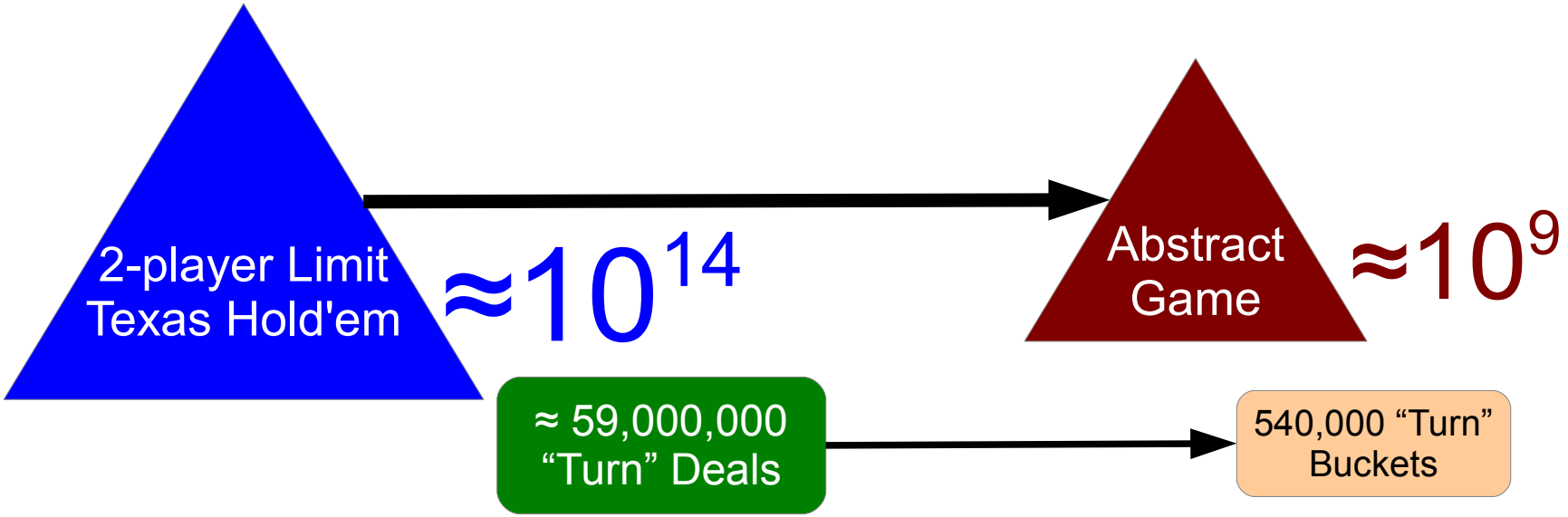
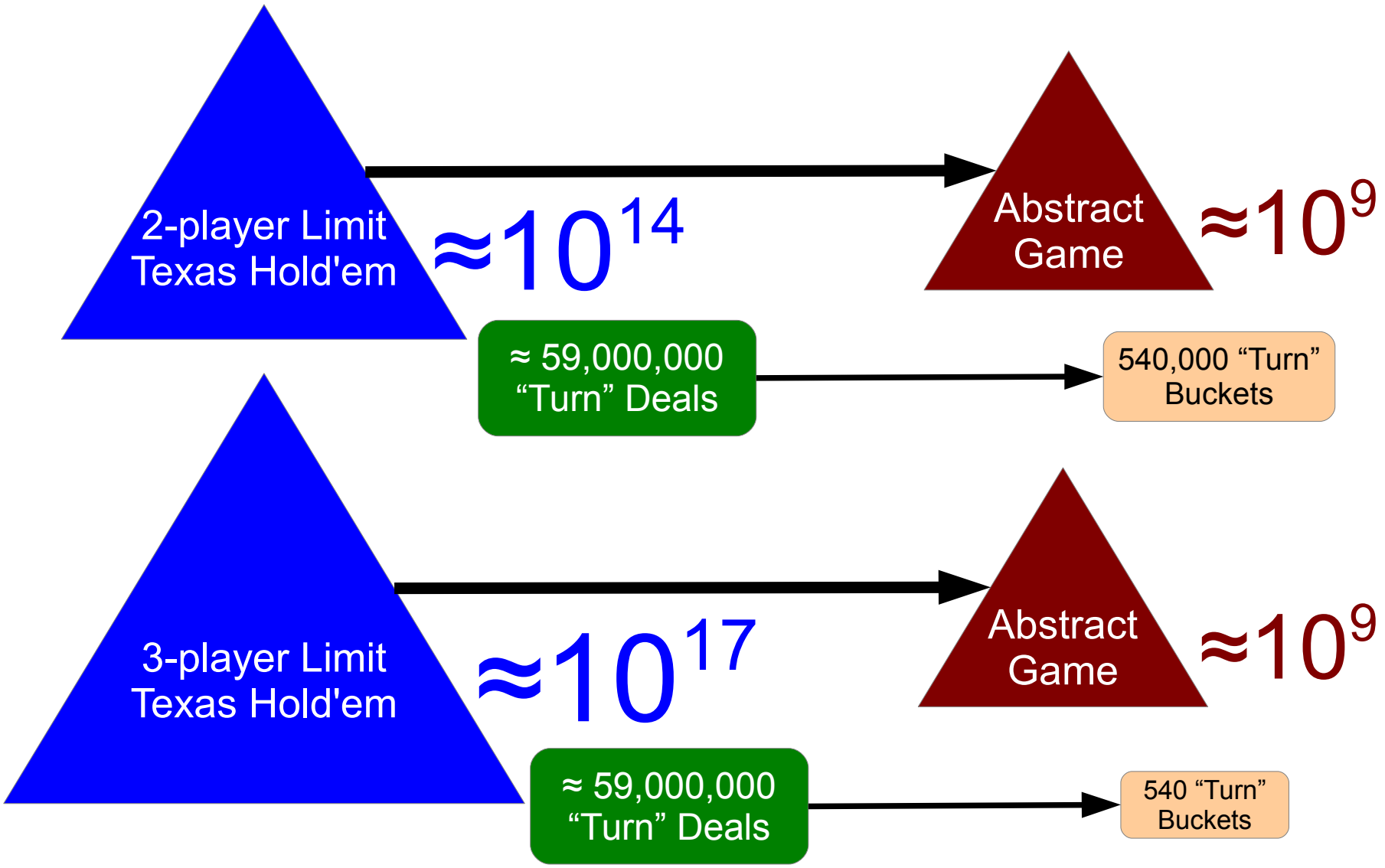


Contribution 2: Strategy Stitching

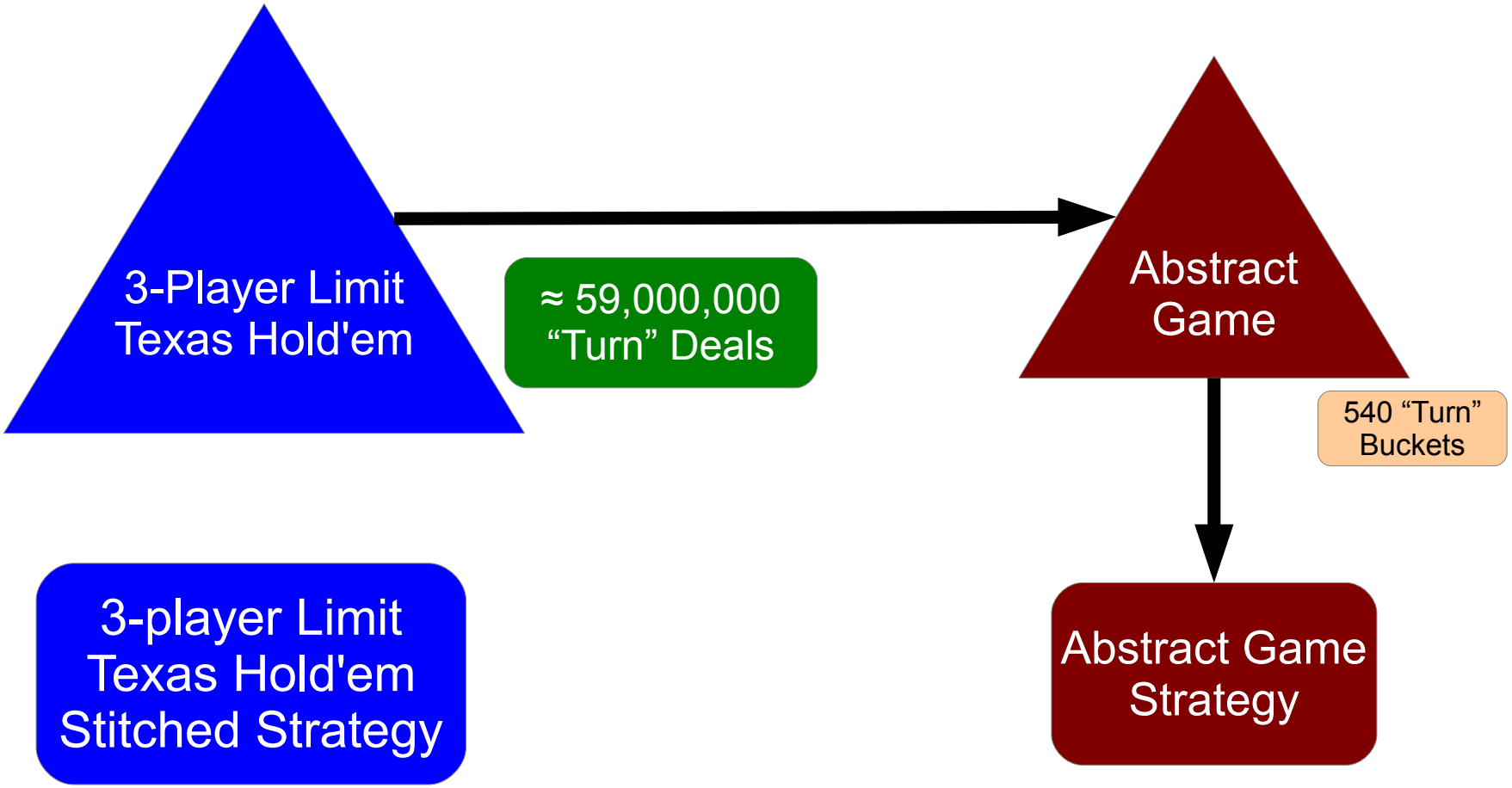
Strategy Stitching



Strategy Stitching

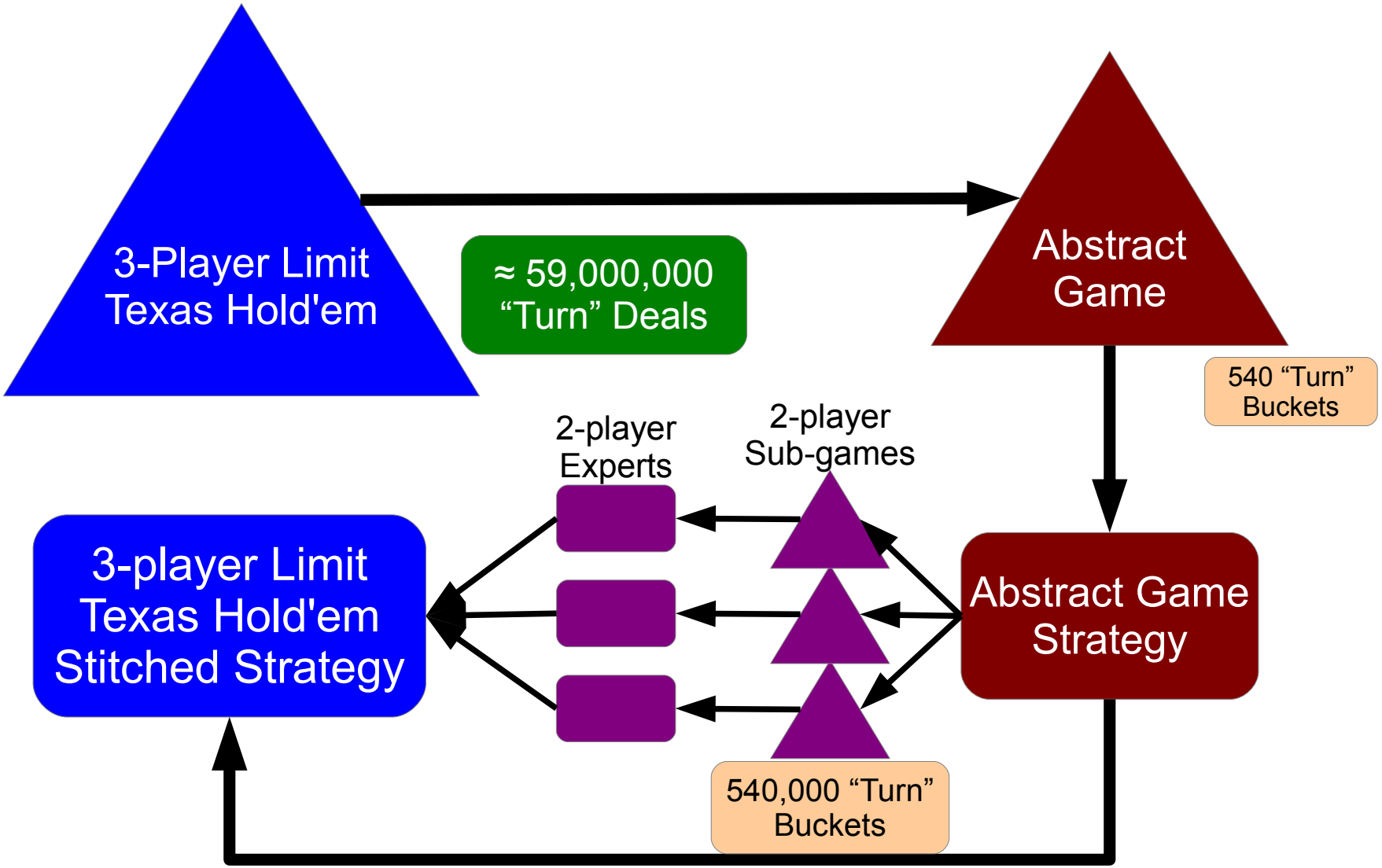


Strategy Stitching



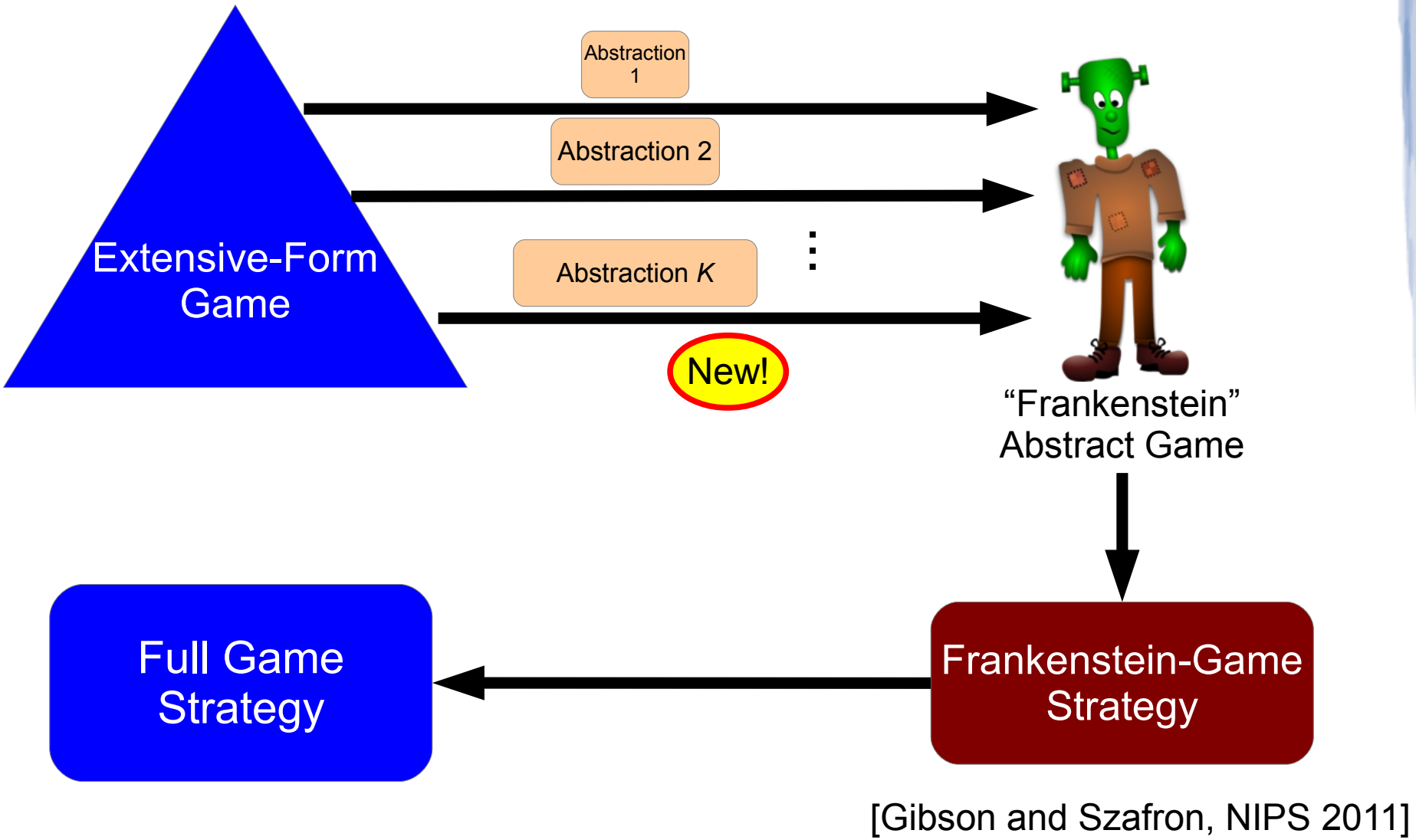
3-player Limit Texas Hold'em Stitched Strategy

Strategy Stitching



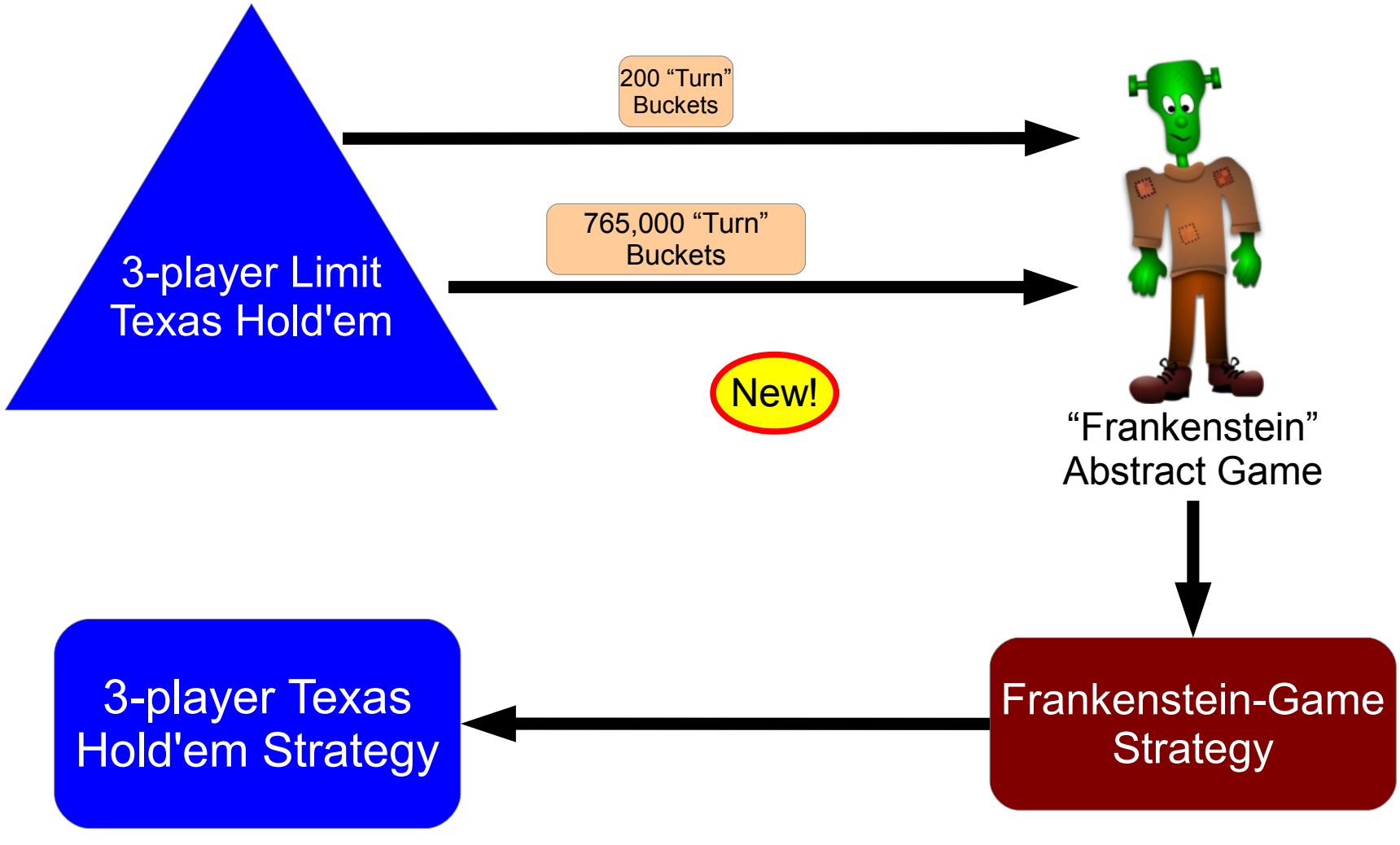
- Generalizes 3 previous approaches [Gibson and Szafron, NIPS 2011]

Strategy Stitching

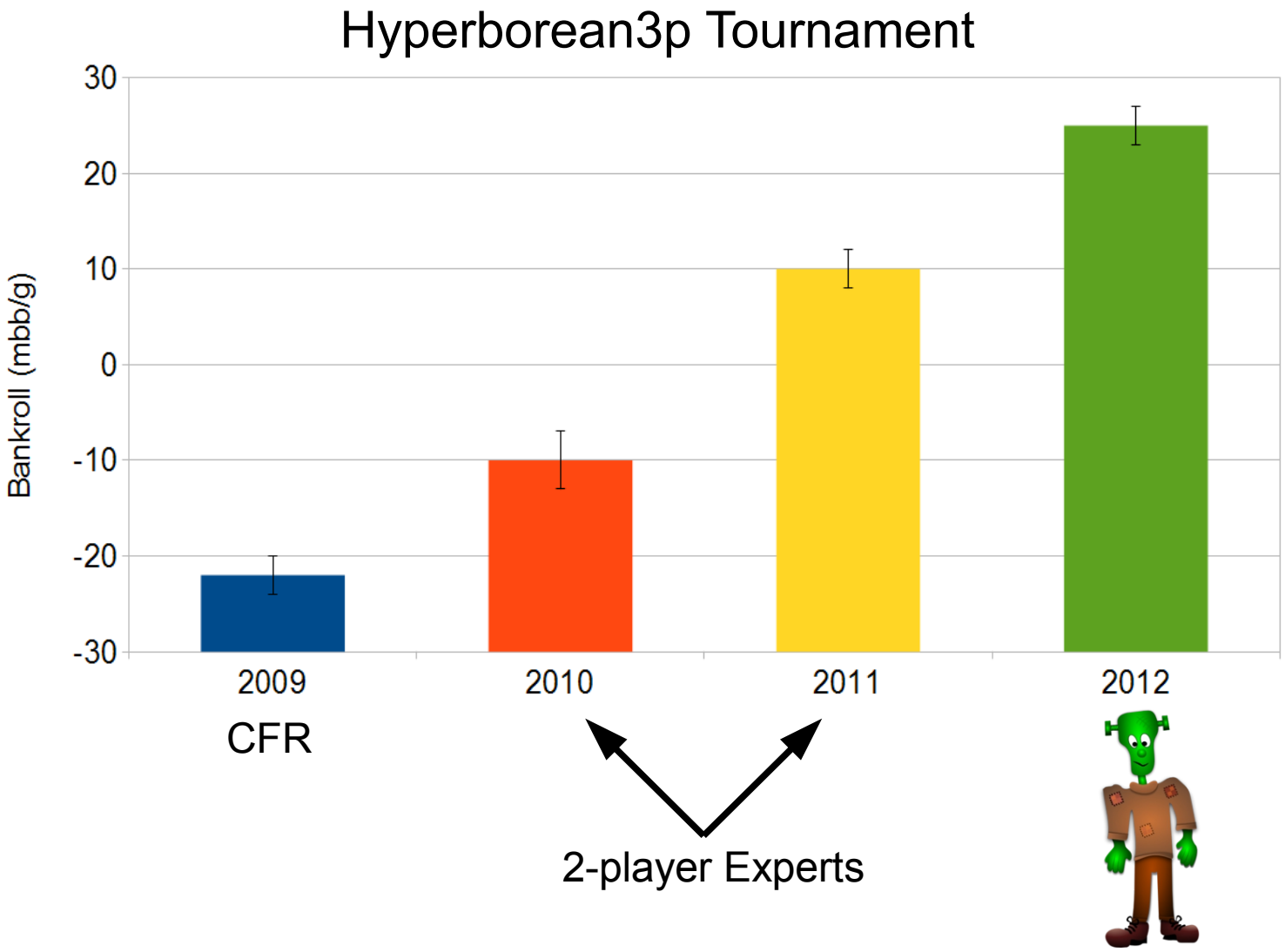


[Gibson and Szafron, NIPS 2011]

Strategy Stitching

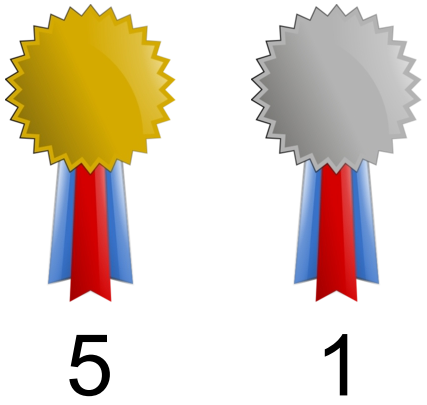


Strategy Stitching



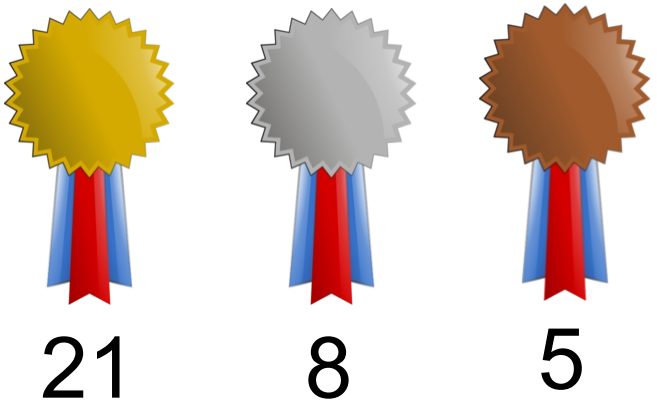
Poker Competition Results

- 3-player Hold'em 2010 – 2012:



- Over all competitions:

  (34/35 top-3 finishes)



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StarCraft AI

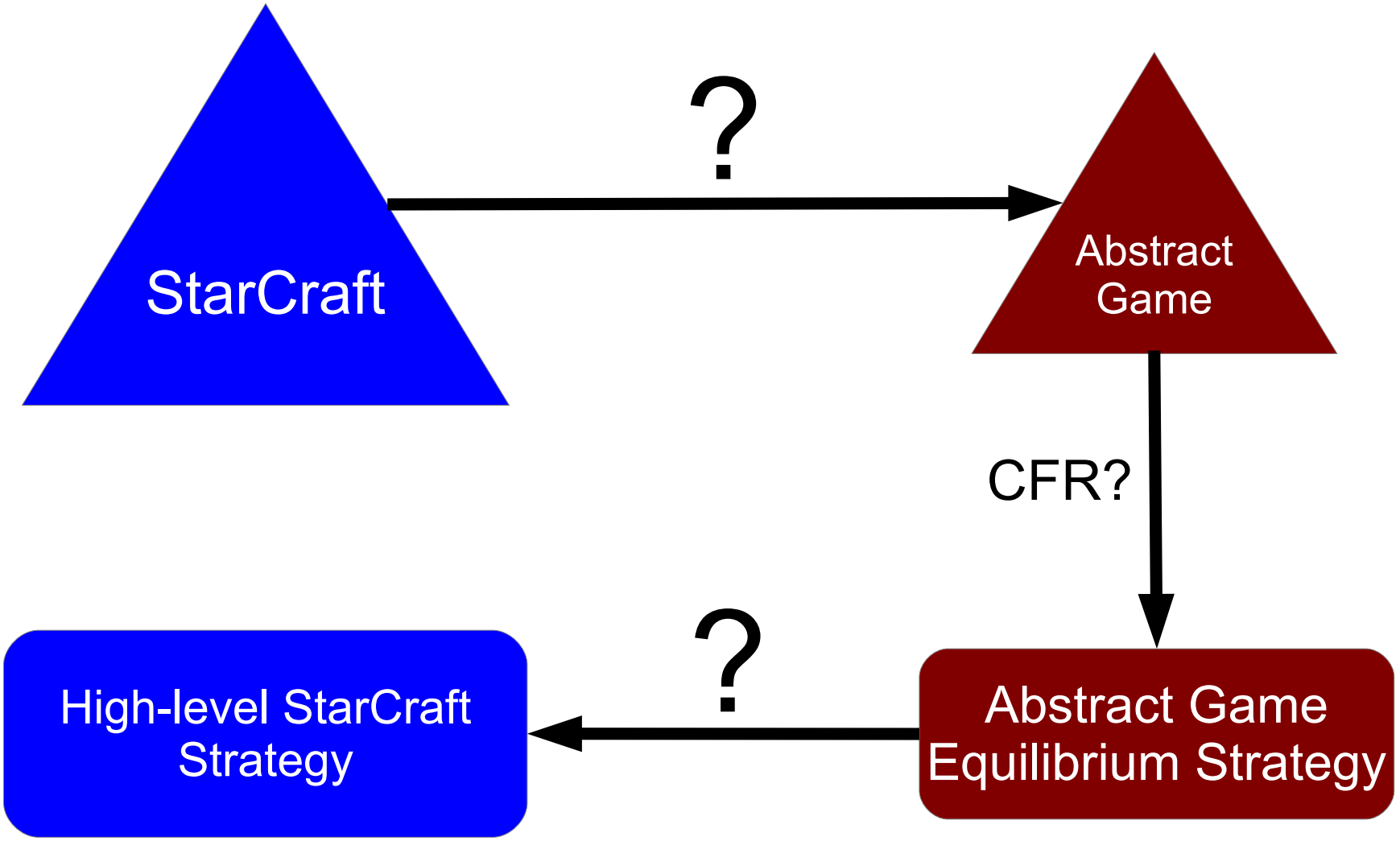
- Real-time strategy game with
  - Imperfect information
  - Large state space
  - Actions taken in real-time
- Better AI can help game design
  - Improved single player experience
  - Game balance

StarCraft AI Competitions

- Annual StarCraft AI Competition at AIIDE
  - Winner plays human professional
  - AI currently no match for humans
  - Poor high-level strategies

Image source: Flickr

StarCraft AI Research



Arcade Learning Environment (ALE)

- Framework for developing AI agents for Atari 2600 games
  - Simple, yet still challenging domains
- Goal: One agent that plays many games well
  - At the heart of artificial intelligence
- Can aid game design
  - Auto-detect glitches
  - Evaluate difficulty
- Future research ideas:
  - Death detection in reinforcement learning

Image source: Wikipedia

Automated Game Content Generation

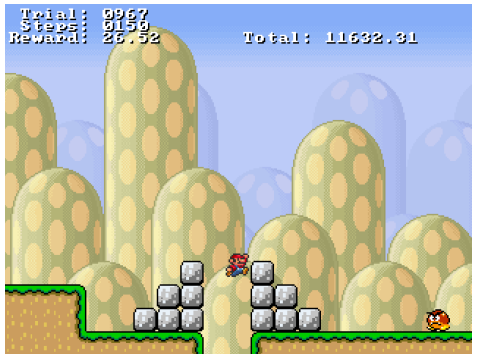


Image source: *Infinite Mario Bros.* screenshot

Image source: nhl.com

- Procedural methods for creating:
  - Levels for a platforming game
  - Music for different game contexts
  - League schedules in a sports game, etc.
- Benefits:
  - More content for “free”
  - Content tailor-made for individual players
- Techniques:
  - Constraint satisfaction + optimization
  - I want to learn more!

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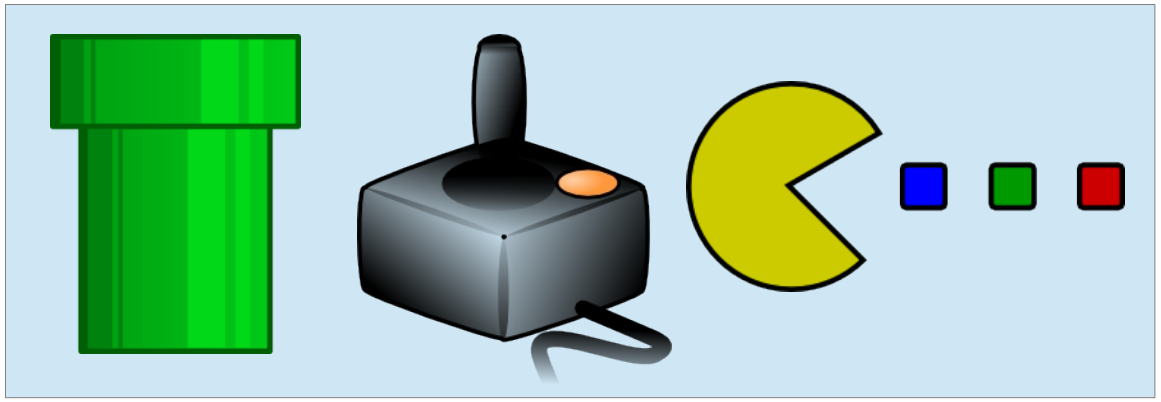
Teaching Interests

- Games design / programming courses
  - IAT 167, 265, 312, 410
  - Experience as lab instructor for introductory programming course
- Establish new courses in AI and games...



AI in Games Courses

- Introductory course
  - Hands-on experience implementing real AI
  - NPC behaviour, simple sports AI, etc.
- Advanced / graduate course
  - Exposure to research in the field:
    - Pathfinding
    - StarCraft AI
    - Interactive story-telling...

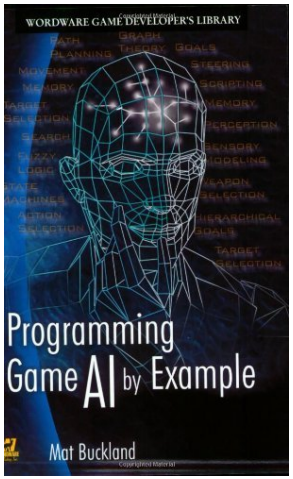
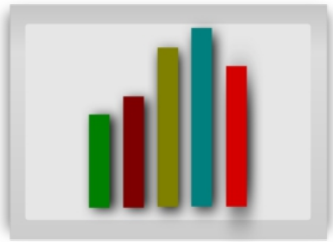


Image source: amazon.ca

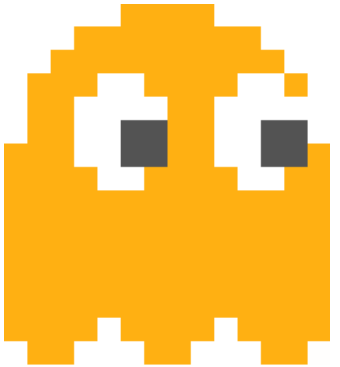


Conclusion

- Computer poker research
  - Primary author of Hyperborean3p
  - Success in poker competitions
- Video game research in StarCraft, ALE, automated game content generation
- Interested in teaching game design and AI in games

Thanks for Listening!

- I'm really excited to be here!
- Contact info:
  - Email: rggibson@cs.ualberta.ca
  - Website: http://cs.ualberta.ca/~rggibson/
  - Twitter: @RichardGGibson



Clip art images used in this presentation can be found at clker.com