Raising the Stakes

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GAMES Research Group

- Largest AI research group using games
- Classic Games
  - Chess, checkers, go, hex
  - Poker, hearts, spades
- Commercial games
  - Role-playing (Bioware)
  - Sports (Electronic Arts)
  - Real-time strategy (Relic)

Thank You

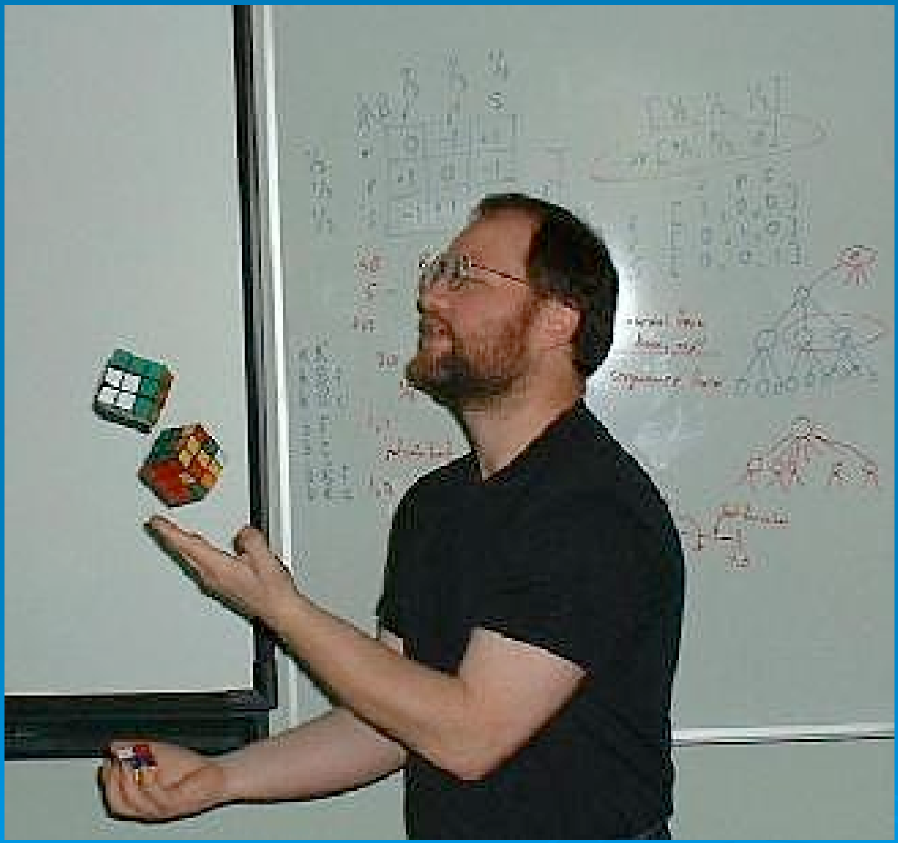
- Darse Billings
- Michael Bowling
- Neil Burch
- Aaron Davidson
- Rob Holte
- Morgan Kan
- Bryce Larson
- Carmelo Piccione
- Terrance Schauenberg
- Finnegan Southey
- Duane Szafron

NSERC CRSNG

INFORMATICS iCORE CIRCLE OF RESEARCH EXCELLENCE

aicml The Alberta Ingenuity Centre for Machine Learning

Darse Billings



Poker player

Philosopher

Computer scientist

Perpetual graduate student

Poker as a Test-bed for AI

- Multiple agents (typically 10)
- Imperfect information (unknown cards)
- Stochastic (shuffled deck)
- Risk management (betting)
- Partial observability
- Opponent modeling

- Unlike most other games-applied research, poker has many properties of real-world applications

Applications

- Adversarial opponent modeling
- Negotiation
- Auctions
- Real-time strategy games
  - Most of the techniques described her have been used for real-time planning in (military) strategy games

Texas Hold'em

- Hundreds of poker variants
- Most strategically complex variant widely played
- *No-Limit* Texas Hold’em used to determine the champion in the annual World Series of Poker
- Our research: ***Limit*** Texas Hold’em
  - 10-player (ring game)
  - 2-player (heads up)

The Goal

The Real Goal

Chris Ferguson

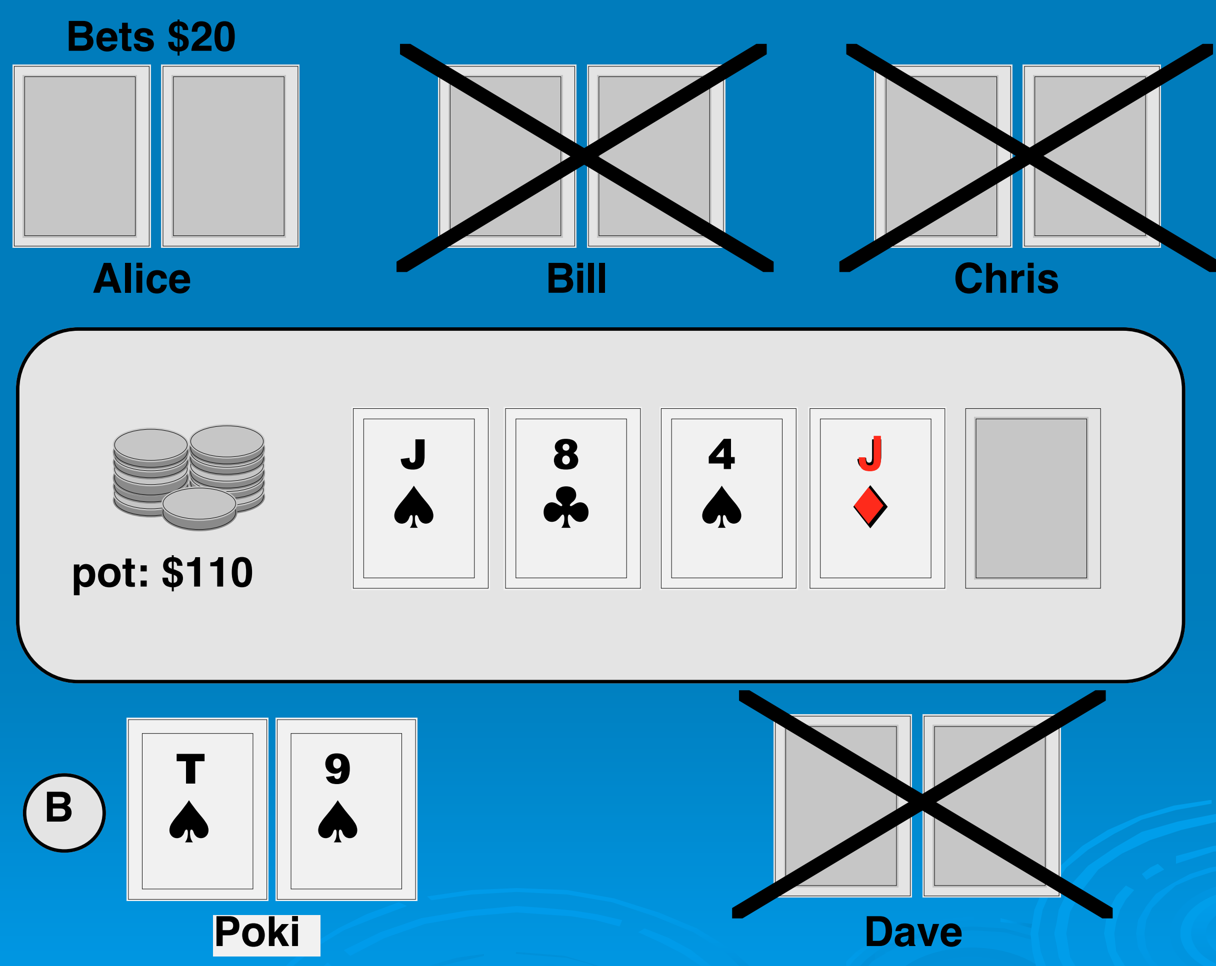
Stu Ungar

Annie Duke

Texas Hold'em Rules

- 2-10 players
- Four rounds of play
  - Pre-flop: Each player gets two private cards; bet
  - Flop: Three community cards; bet
  - Turn: One community card; bet
  - River: One community card; bet
- Betting:
  - fold (lose all you money)
  - check/call (match what is in the *pot*)
  - bet/raise (increase amount in the *pot*)
- Best five card poker hand wins

Texas Hold'em Example



Obstacle 1: Feeling Lucky?

Obstacle 2: Does He Have It?

Obstacles (3)

- Imperfect Information
  - Few data points
  - Probabilistic strategies are essential
  - Need to infer what the opponent is likely to have (modulo bluffing)
- Opponent Modeling
  - Every opponent has a different style
  - Opponents change style frequently
  - One cannot be predictable!

Building a Strong AI 1991-2005

- Rule-based (bad)
  - Loki (1995-1997)
- Simulations (better but weak)
  - Loki -> Poki (1997-present)
- Game theory (good)
  - PsOpti (2001-present)
- Learning and adaptation (best?)
  - Vexbot (2003-present)
  - Bayesbot (2005-present)

Rule-based Strategy

- Need a *real* domain expert (which we had)
- Poker knowledge is fragile
  - Covered common cases reasonably well
  - Unable to properly recognize and handle exceptions
- Poker expert quickly becomes the bottleneck, applying Band-Aid solutions to fix problems
- Easily exploitable by an experienced player
- Loki could win at a good rate in Internet games

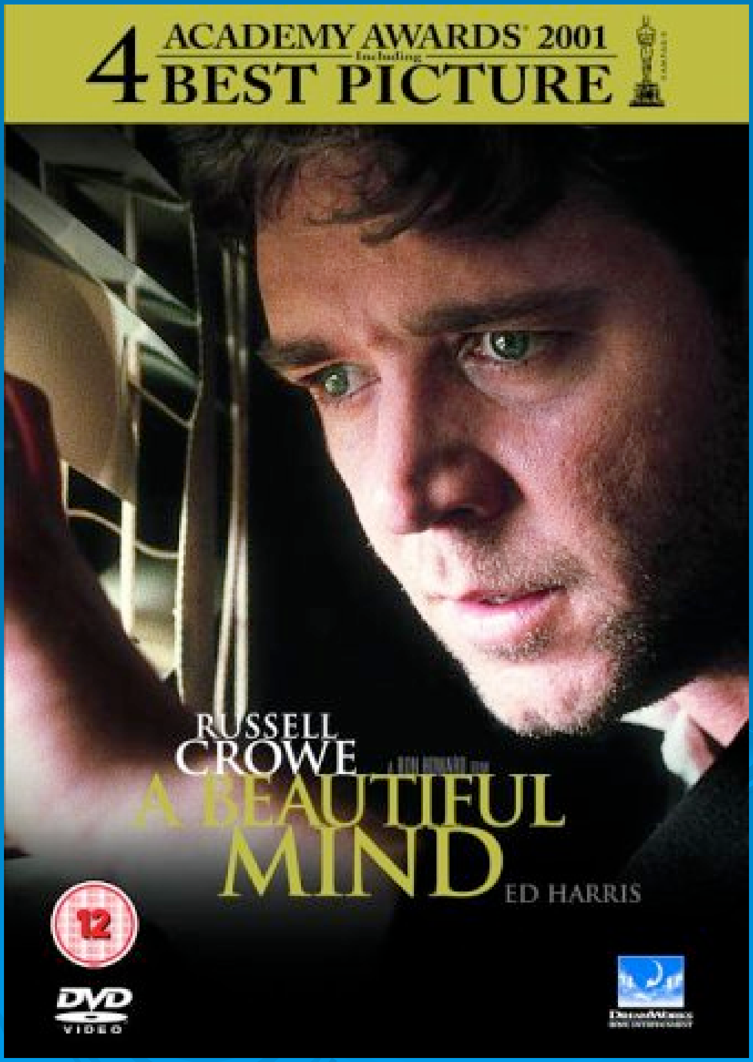
- The most knowledge-intensive strategy tried

Simulations Strategy

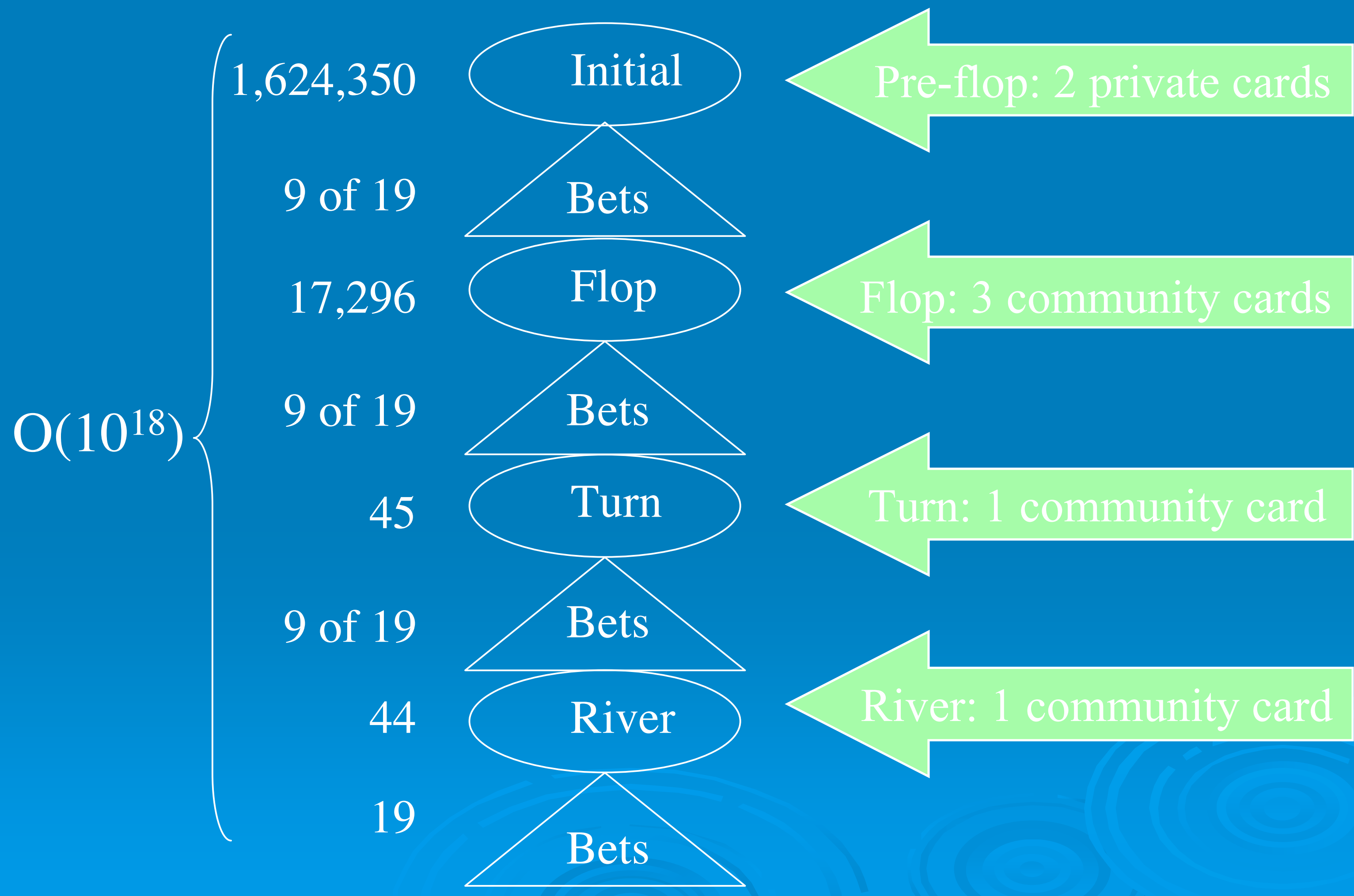
- For each betting decision (f/c/r):
  - “Deal” cards to the opponent
  - Simulate hand to end of game
  - Gather statistics on each decision
- Less reliance on expert knowledge
  - Search is knowledge!
- Reliant on having a good model of the opponent
- Stronger than Loki in the laboratory, but not that much stronger against humans
- Less expert knowledge -> better play

Game Theory

- Nash equilibrium
- Find an "optimal" answer
- Assumes both sides play perfectly
- Recipe for drawing matches against strong players



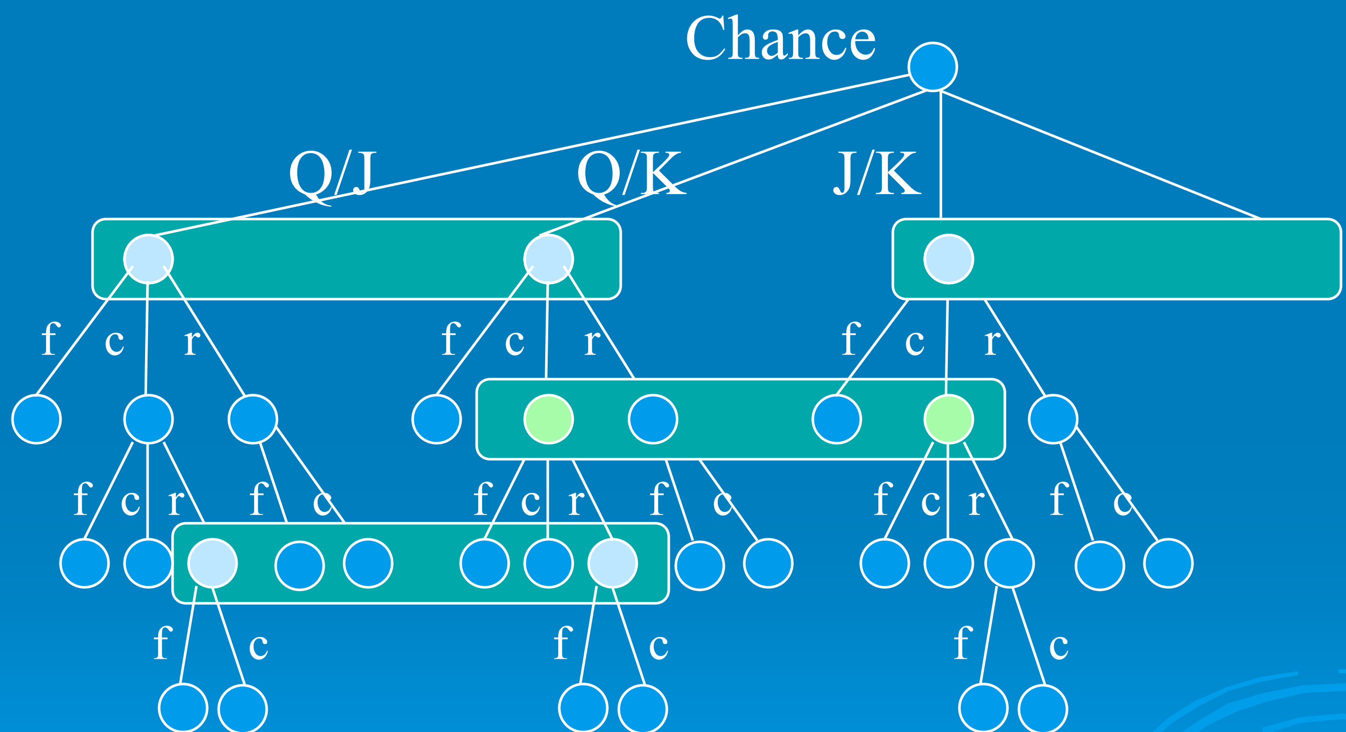
Two-player Limit Hold'em



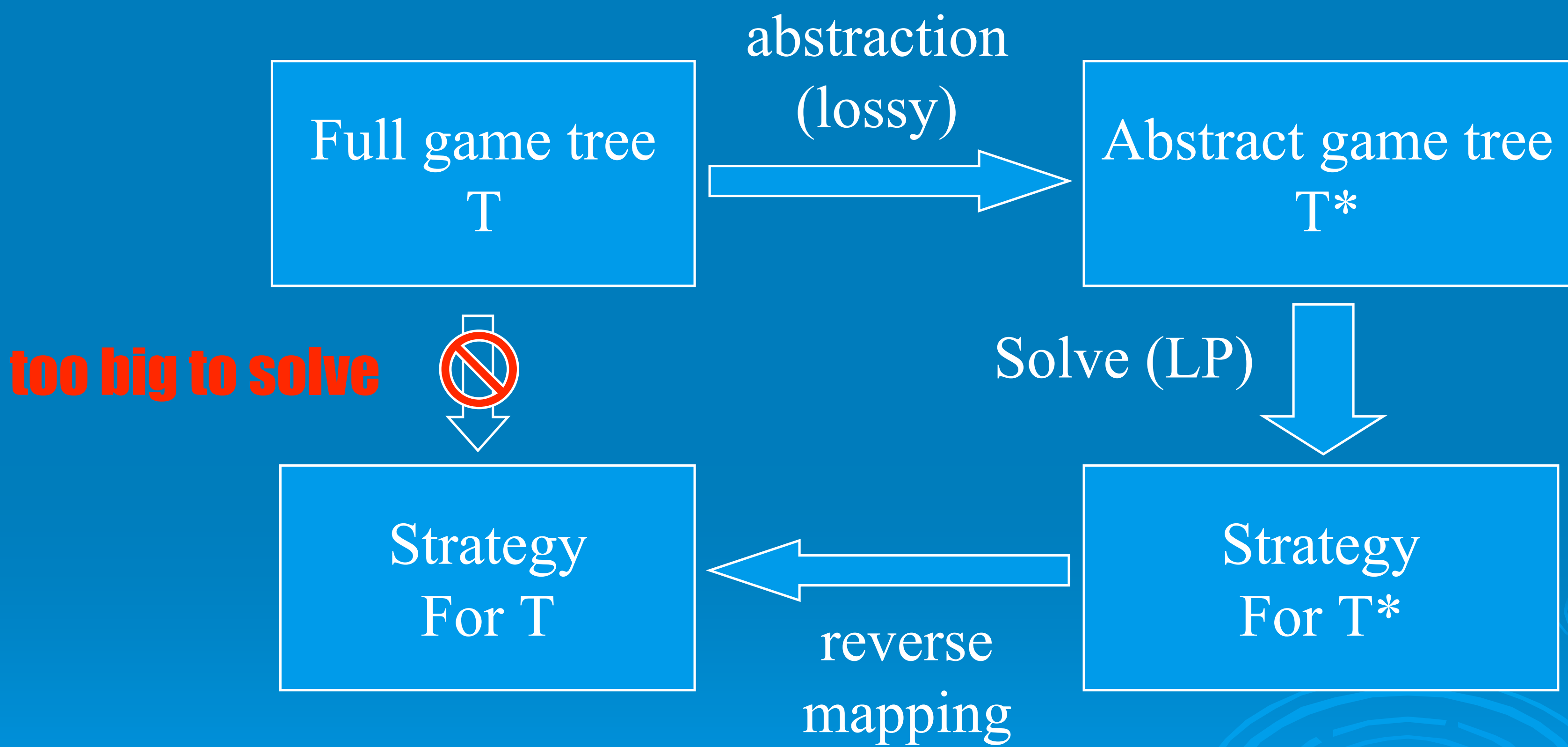
Optimal Play

- Solve a linear programming problem for two-player Hold'em
- An axis is all possible *information sets* for each player
  - An information set is a set of states in the search tree where the player could be
  - Can't know for sure because of hidden information

Information Sets



Abstraction

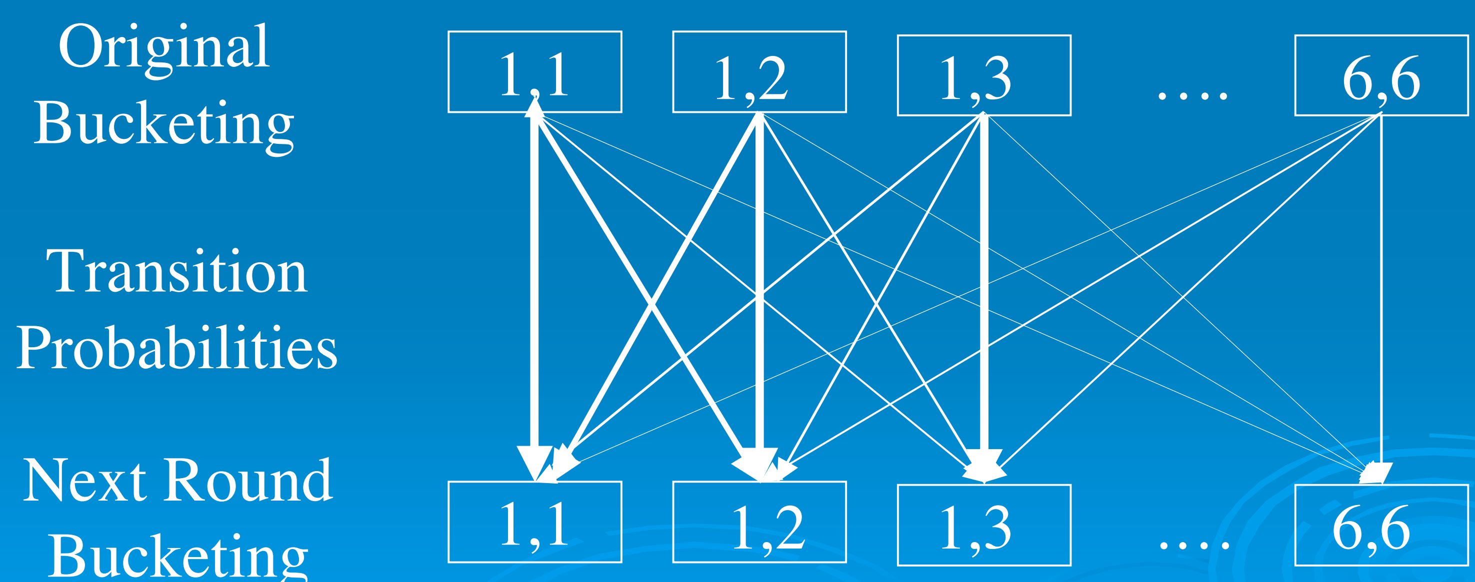


Pseudo-optimal Solution

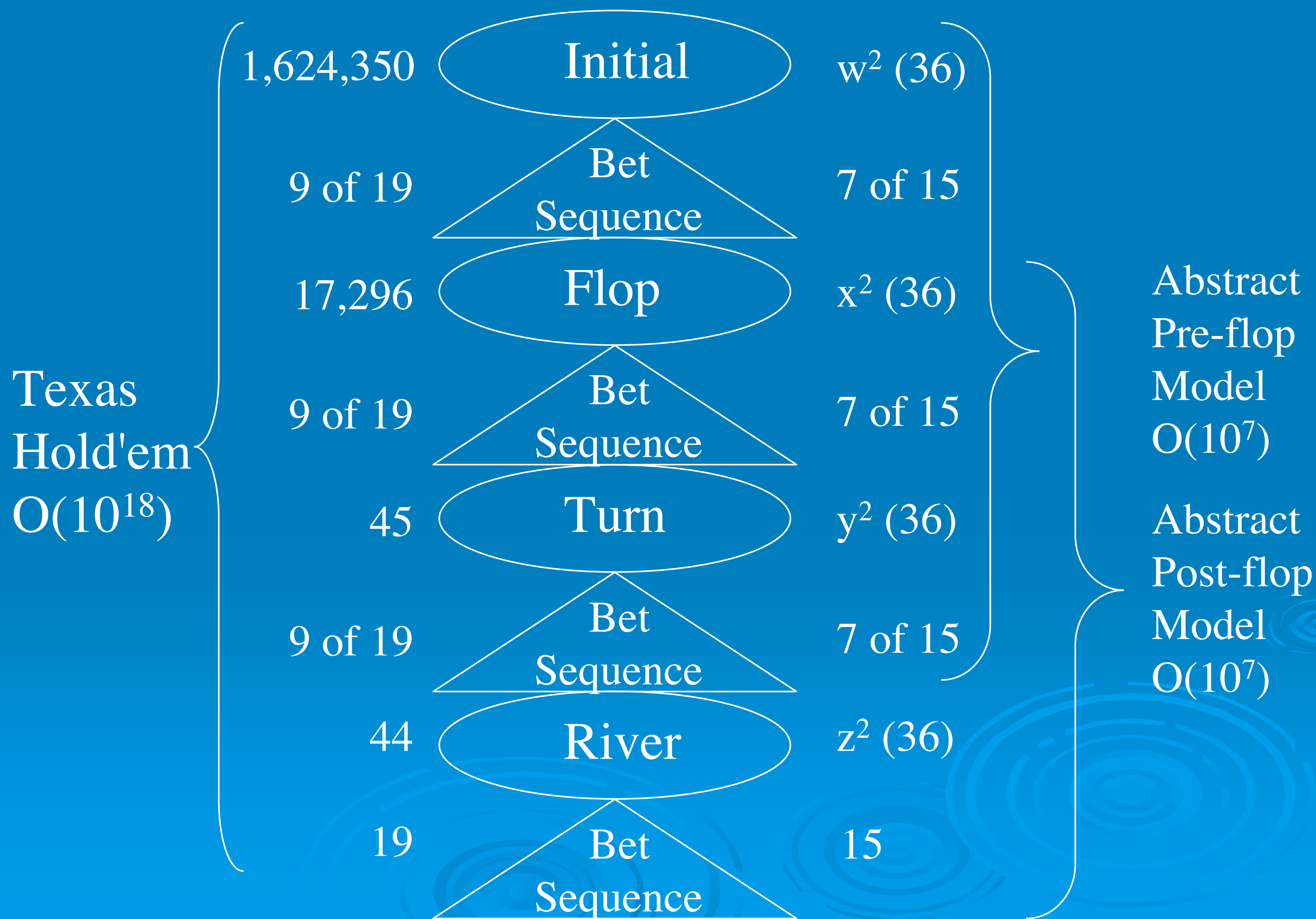
- Pretend that you and your opponent can have only one of 6 types of hands
  - fantastic, very strong, strong, pretty good, so-so, weak
- This new game is 100 billion times simpler than real poker
- This new game looks like poker… and use its solution to play real poker.

Bucketing

- Reduce branching factor at chance nodes
- Overlaying "strategically similar" sub-trees



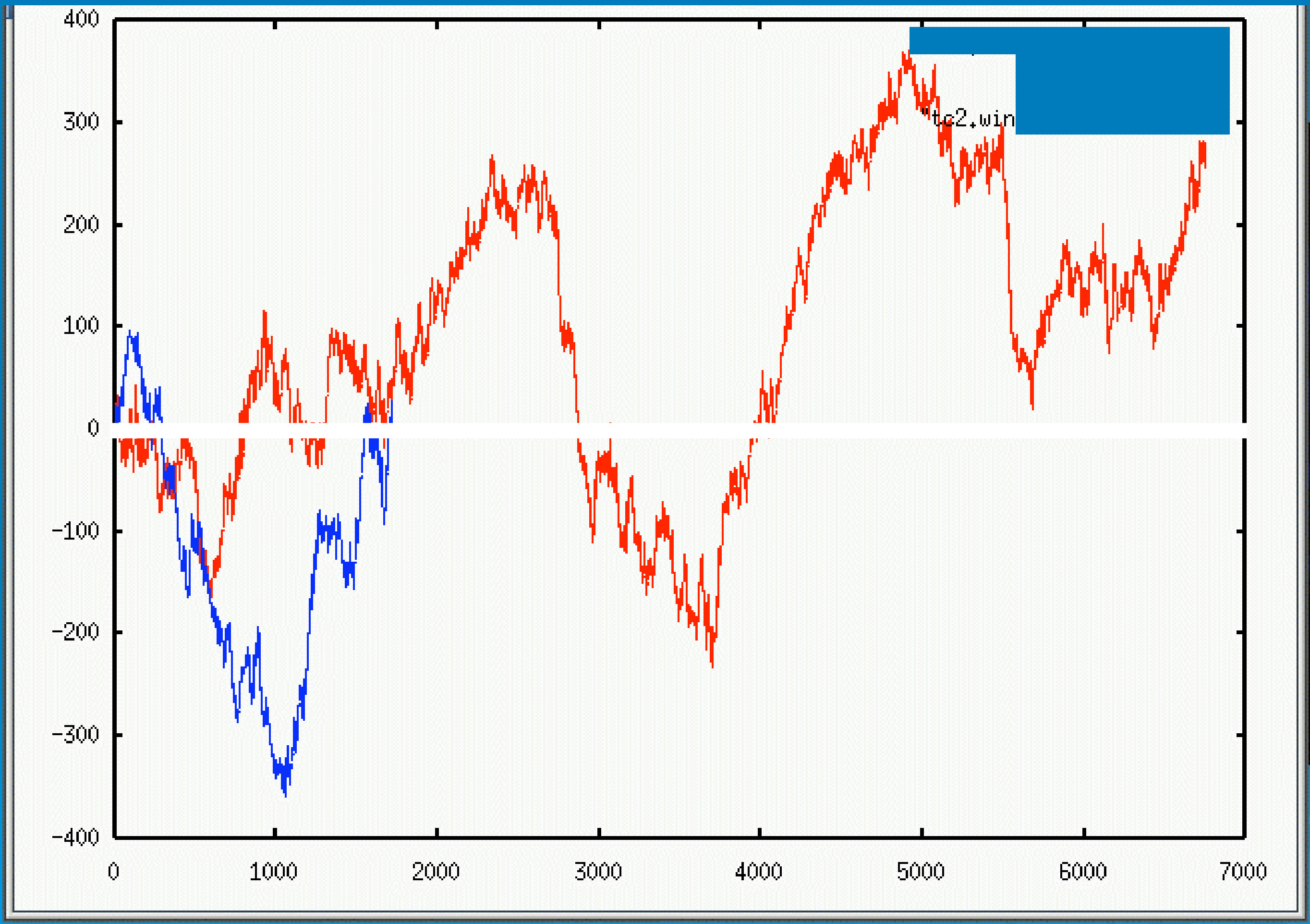
Abstraction Models



Solving the LP

- Generates a system of equations
  - 10,000 to 100,000 entries per player
  - Sparse; 100 non-zero entries per row/column
  - Needs 24 hours to solve on an Athlon 1800 with 4 GB of RAM using CPLEX
- Use 7 categories of hands? Gets too big very quickly!

PsOpti2 versus "theCount"



PsOpti

- Pro:
  - Quantum leap in playing ability
  - Poker knowledge used in the abstraction (pre-processing), not in the program (during play)
  - Improved version
- Con
  - It takes a while, but strong players can identify weaknesses and exploit them
  - Program is oblivious to opponent's strategy
  - *Optimal is not maximal*

Human Opinion?

"You have a very strong program. Once you add opponent modeling to it, it will kill everyone."

Gautum Rao

Rock, Paper, Scissors

- 1st & 2nd International RoShamBo Championships
- Deceptively simple problem that illustrates the differences between optimal and maximal play



Iocaine Powder

Adaptive Play

- Numerous standard machine learning attempts (genetic algorithms, neural nets, decision trees, etc.) but with no notable success
- Gather data on opponent decisions and attempt to learn a model of their play

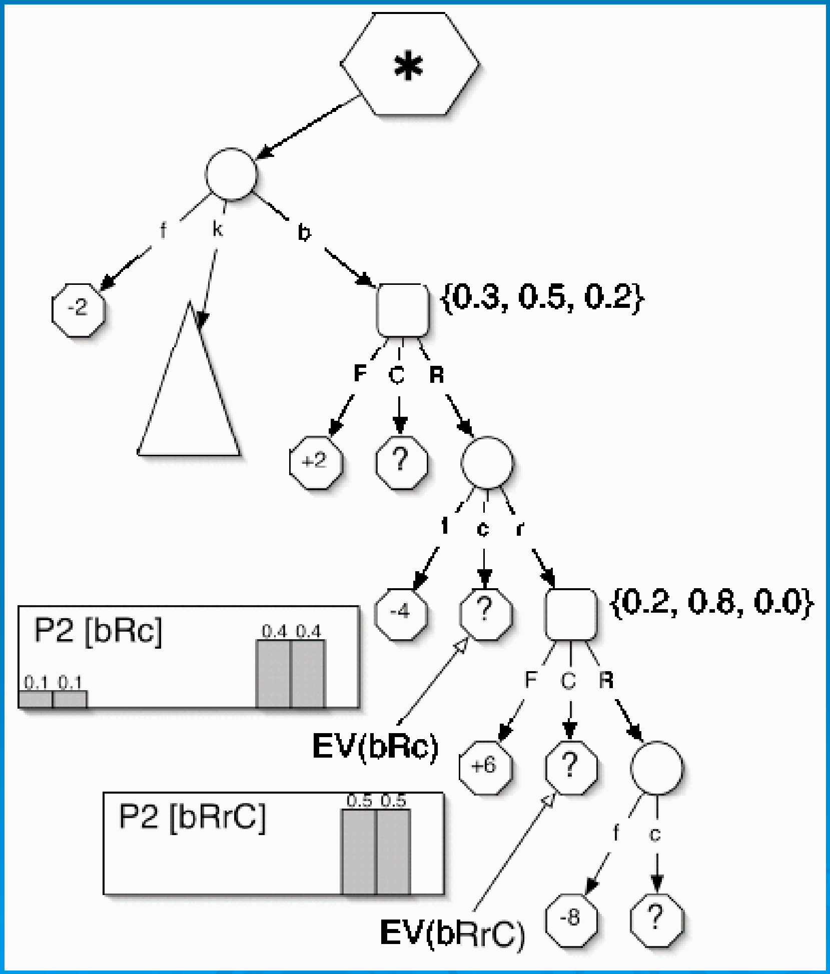
Context Tree (1)

- For each opponent, maintain a *context* tree of all possible betting sequences
  - In a given betting context, keep track of how often the opponent did a f/c/r
- To compute a betting decision, search the tree and compute an expected value
- Need:
  - Assign a value to the leaf nodes
  - Assign f/c/r frequencies to betting nodes

Context Tree (2)

- Use a variation of Expectimax
  - Value of a node is the sum of the weighted value of each of the children
- For opponent's decisions, use a mixed strategy
- For program's decisions, use a maximum or mixed strategy
- Miximix and Miximax algorithms

Using a Context Tree



Obstacles

- Few data points for a given betting context
  - Treat "similar" scenarios the same way, allowing one to abstract multiple contexts into one context
- Leaf node data is sparse
  - Use empirical data when we have it, else infer a "reasonable" distribution based on the betting sequence
- Default seeding of the tree
  - Defaults from a strong player or from PsOpti don't work; they are each skewed to a particular style

Results

- Vexbot handily defeats PsOpti and all our other bots by large margins… over 40,000 hands
- Results against humans are mixed, ranging from brilliant to mediocre
- Vexbot needs to learn quickly and start winning within 50 hands

Bayesbot

- Use a different model of a game based on probability distributions
- Accelerate learning by classification
- For each player (parameter space):
  - Level 1 (4 options):
    - Betting frequency, folding frequency, bluffing frequency, trapping frequency
  - Level 2 (4 options):
    - Preflop, flop, turn, river
  - Level 3 (4 options):
    - Bet level (bet, raise, re-raise, cap betting)

Bayesbot

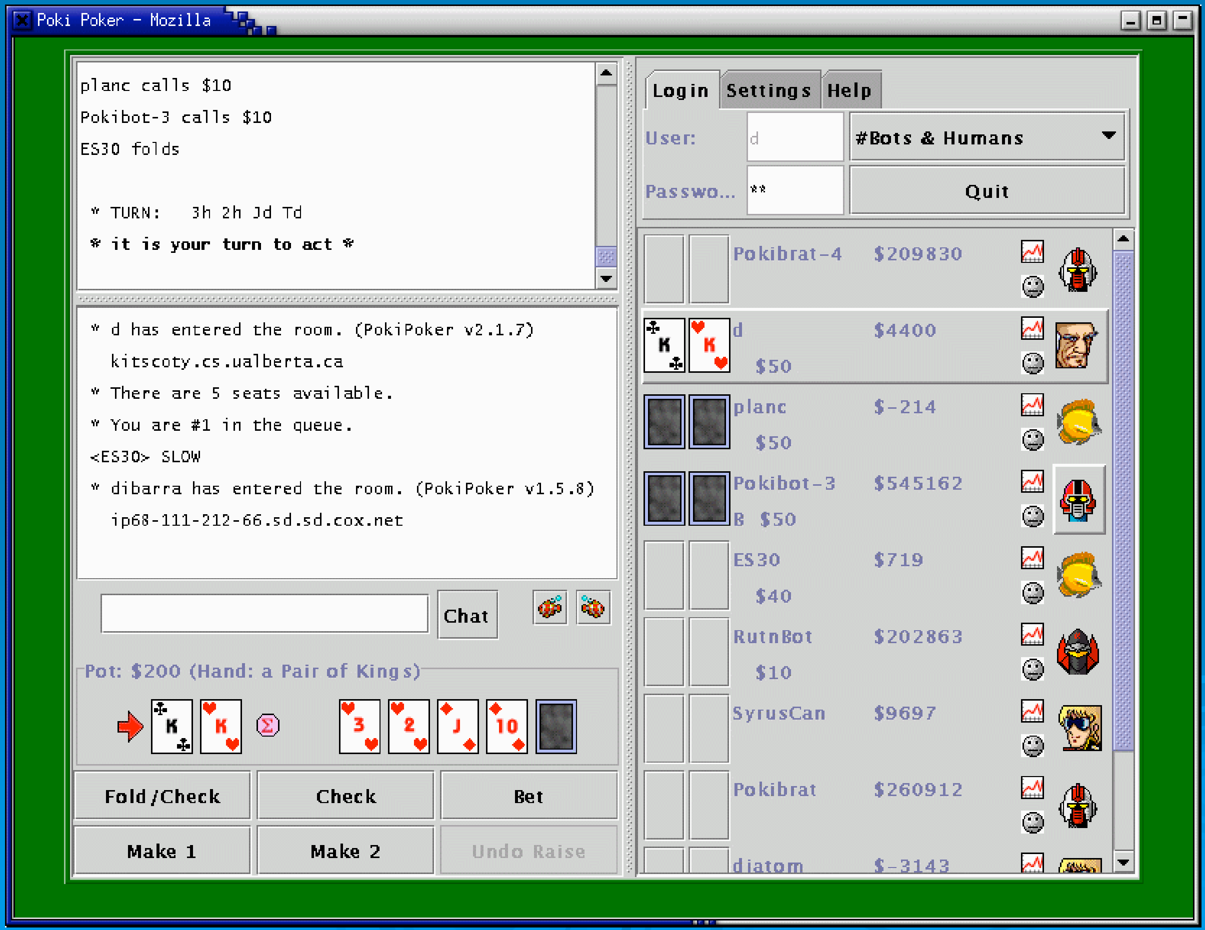
- Algorithm
  - Start with a random model
  - Play a hand
  - Use Bayesian inference to a move to a model that better approximates the data seen
  - Play a hand with the new model and repeat step above
- Simplifications
  - Subset of the the complete abstraction model
  - Use 10 values to approximate distribution
- Early stages, but results are very promising

Conclusions

- Poker is a challenging AI domain (if only I had realized this in 1991)
- Optimal strategy is a misleading concept; maximal play will win more money
- Adaptive bots hold the key to world-class poker play
- Current program might be an even-money bet against a top player

Play Online!

http://games.cs.ualberta.ca/poker/

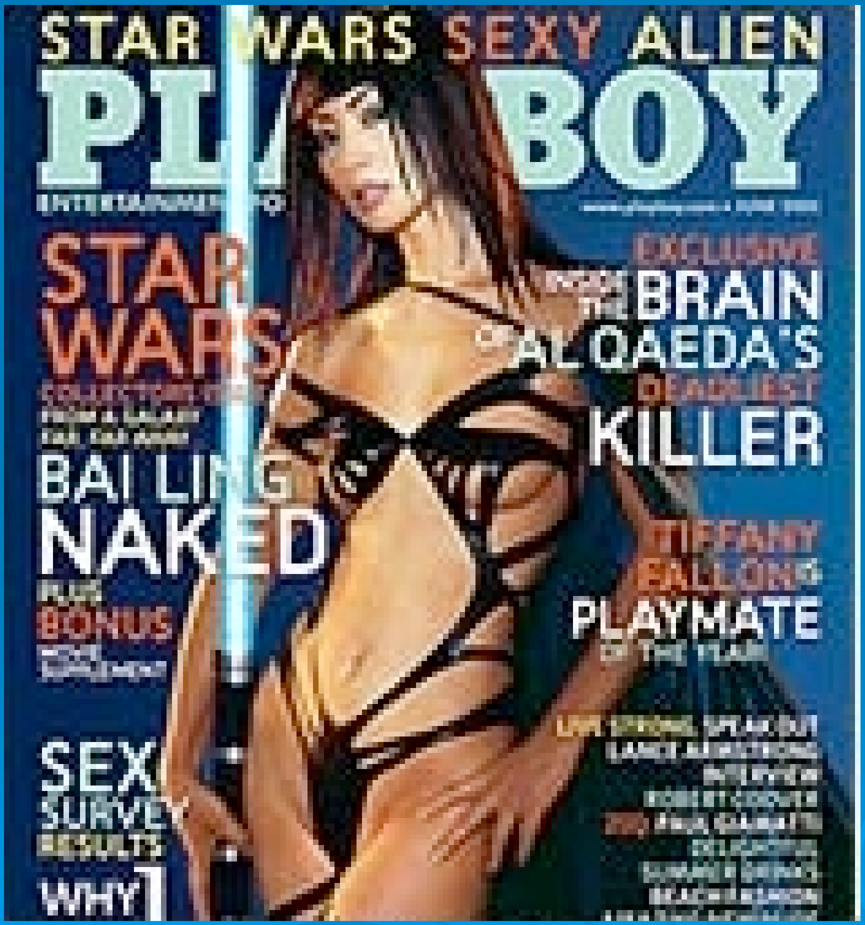


Better Yet… Buy it :)

http://poki-poker.com

http://poker-academy.com

Publicity!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