IT3105 – Artificial Intelligence Programming

Kai Olav Ellefsen

3 Lecturers

- Kai Olav Ellefsen, PhD Candidate
  - Project on autonomous poker playing

- Helge Langseth, Professor
  - Project on speech recognition

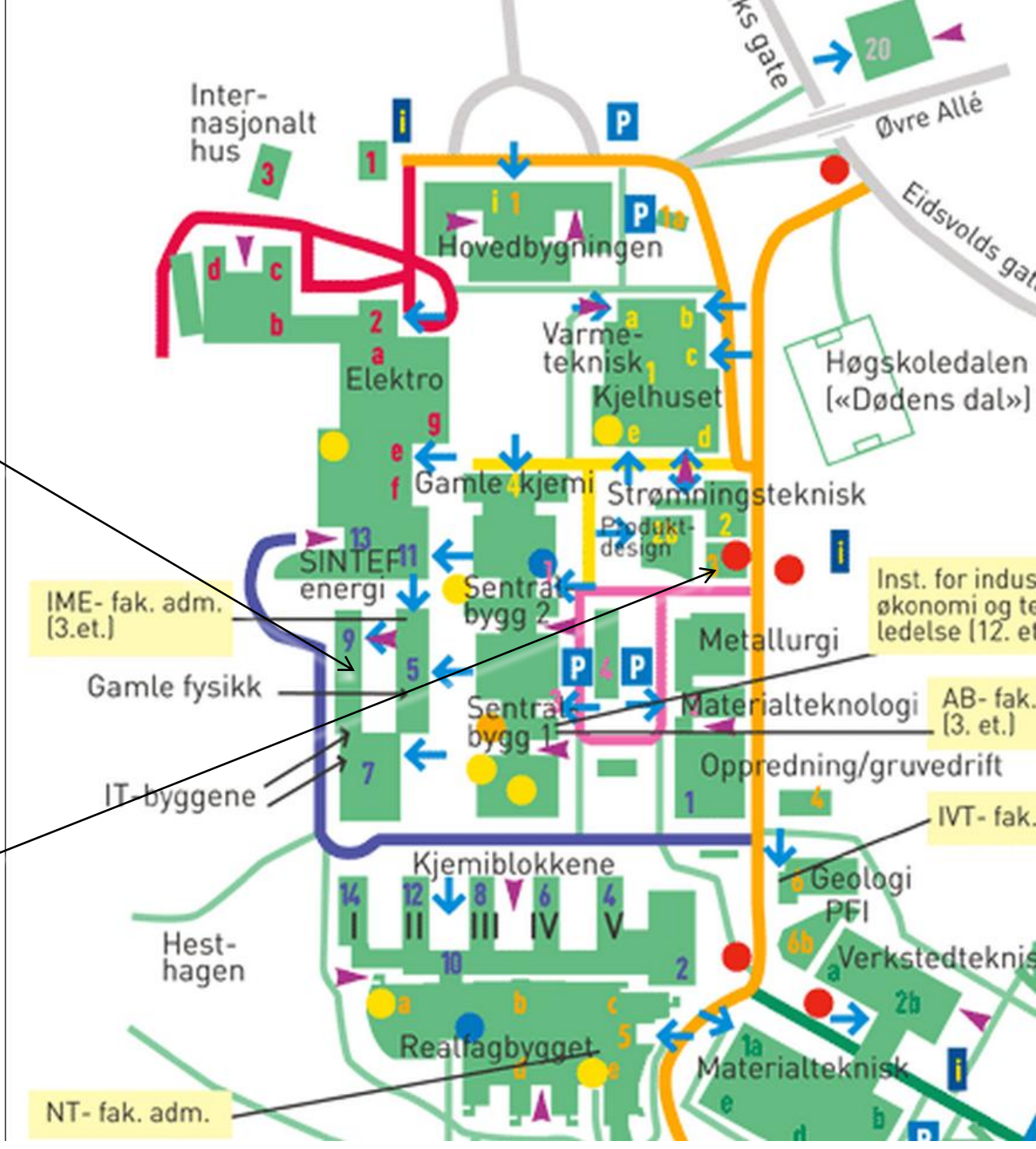
- Erwin Marsi, Research Scientist
  - Project on natural language understanding

Student Assistant

- Kim Verner Soldal
- Room 424, Høyskoleringen 3 (P15):
  - Tuesday, Wednesday, Thursday 10-12

Teachers are in IT-Vest, 3rd floor

Computer lab is in «P15»



3 Projects

- Approx. 1 month per project
- Delivery dates:
  - Project 1: September 21.
  - Project 2: Late October
  - Project 3: Late November
- Final grade = (1/3) * Proj1 + (1/3) * Proj2 + (1/3) * Proj3
- Groups of two allowed

Lecture plan

- http://www.idi.ntnu.no/emner/it3105/lectures/index.php

Updated Info

- Webpage:
  - http://www.idi.ntnu.no/emner/it3105/index.php
- It's Learning:
  - https://www.itslearning.com/Main.aspx?CourseID=40253
- Mailing list:
  - http://www.idi.ntnu.no/emner/it3105/mailinglist.php

QUESTIONS ABOUT THE COURSE?

Project 1:

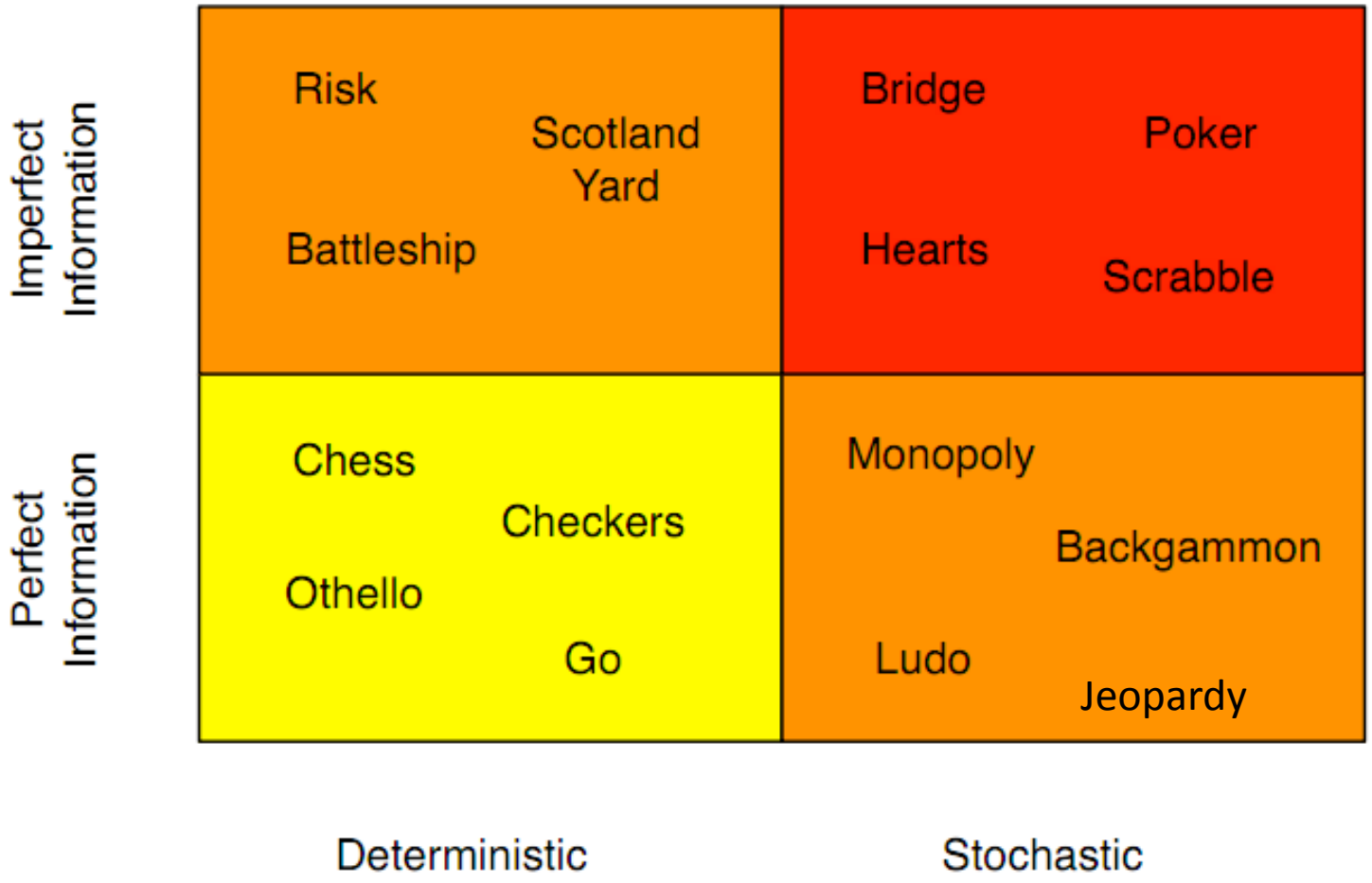
TEXAS HOLD'EM

Source: Wikimedia Commons (By Todd Klassy)
URL: http://commons.wikimedia.org/wiki/File:Holde

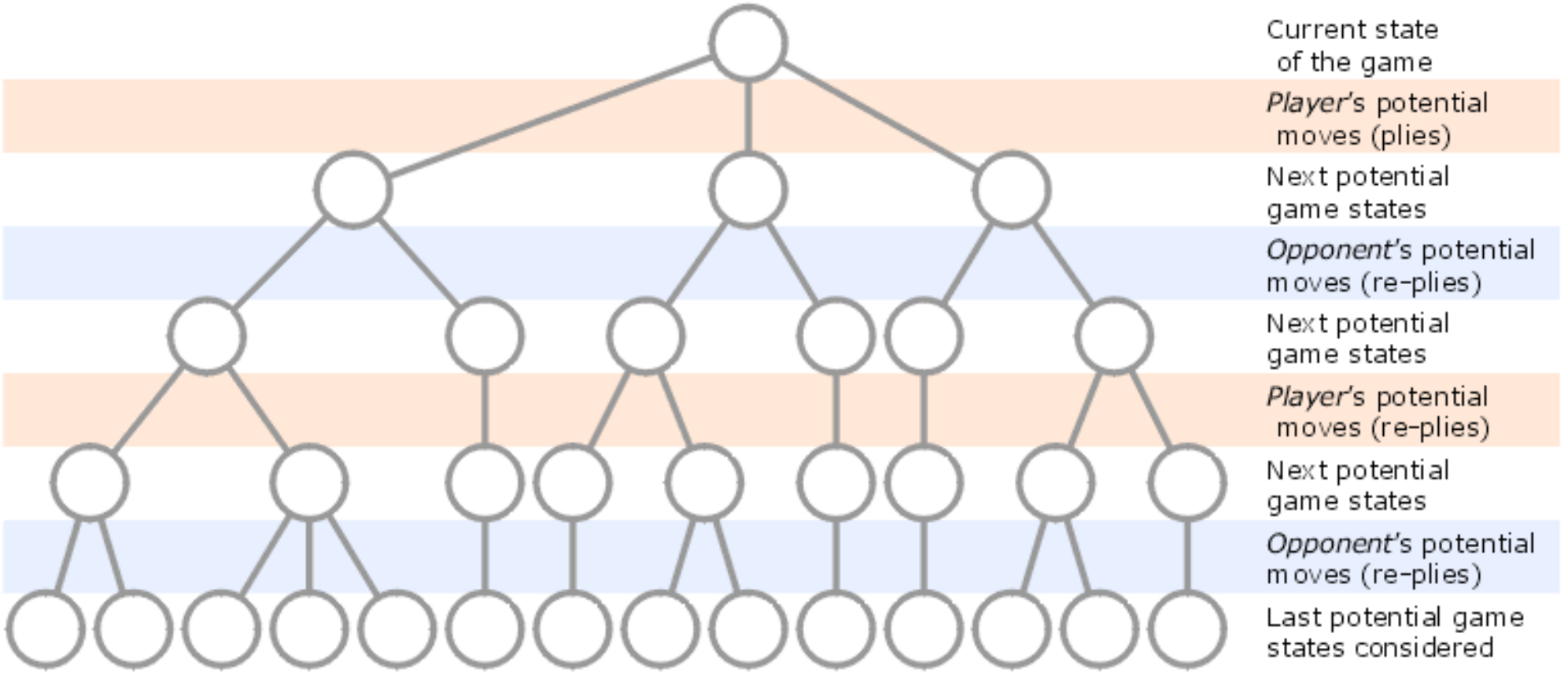
A.I. and Games

- TD-Gammon (1992)
- Deep Blue vs. Kasparov (1997):
  - http://www.youtube.com/watch?v=y9UMt-8gfW8&feature=related
  - *"Well, at least it didn't enjoy beating me."*
- Watson (2011):
  - http://www.youtube.com/watch?v=FC3IryWr4c8

Game Classification



The Minimax algorithm (for deterministic games)

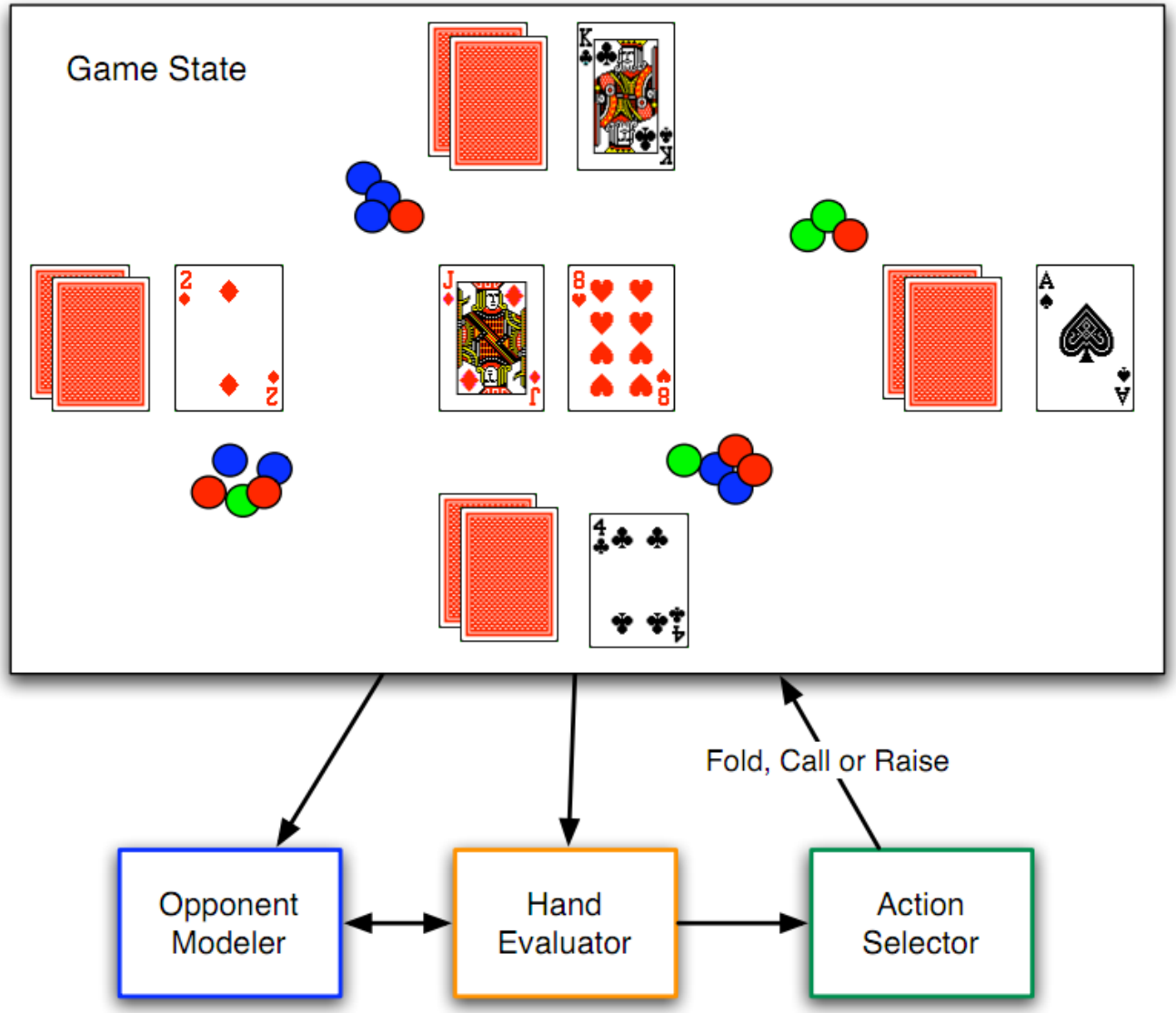


Source: Wikipedia (http://en.wikipedia.org/wiki/File:Plminmax.gif)

What About Poker?

- Earlier, focus often on simplified versions / subsets of game.
- Recent approaches often model entire game:
  - http://www.idi.ntnu.no/emner/it3105/book/index.php
- Polaris (2008) won Heads-Up turnament against some of the best human players.
- Annual poker-bot competitions:
  - http://www.computerpokercompetition.org/index.php?option=com_content&view=article&id=79%3Aresults-2010&catid=36%3Aresults&Itemid=61&limitstart=1

Elements of an AI Poker Player

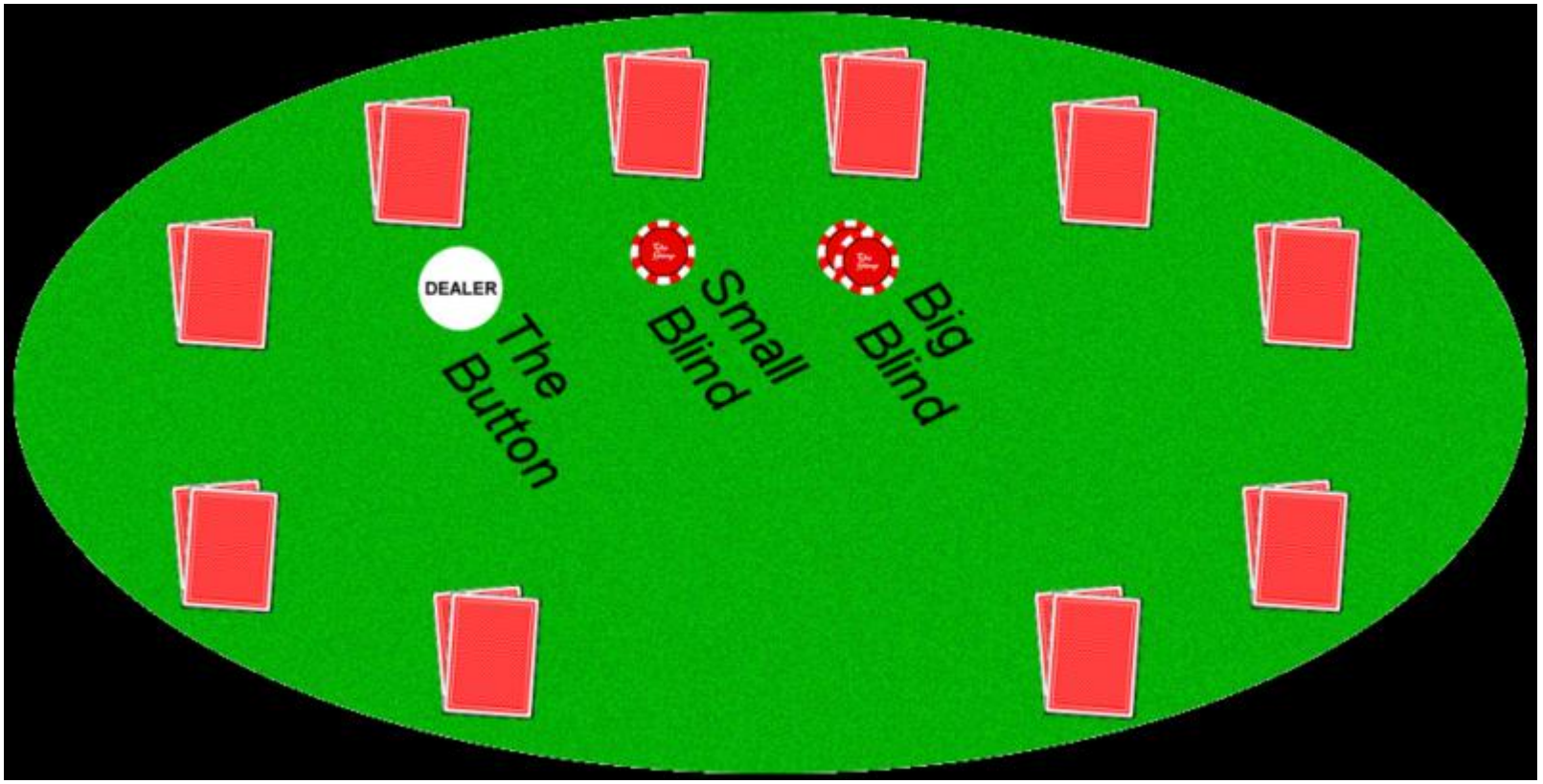


Texas Hold'em Rules

- Each game consists of many *hands*. The winner(s) of any hand take the *pot*.
- Keep playing hands until tournament is done.
- Winner of a hand is the player with the best cards at the end

How a Hand is Played

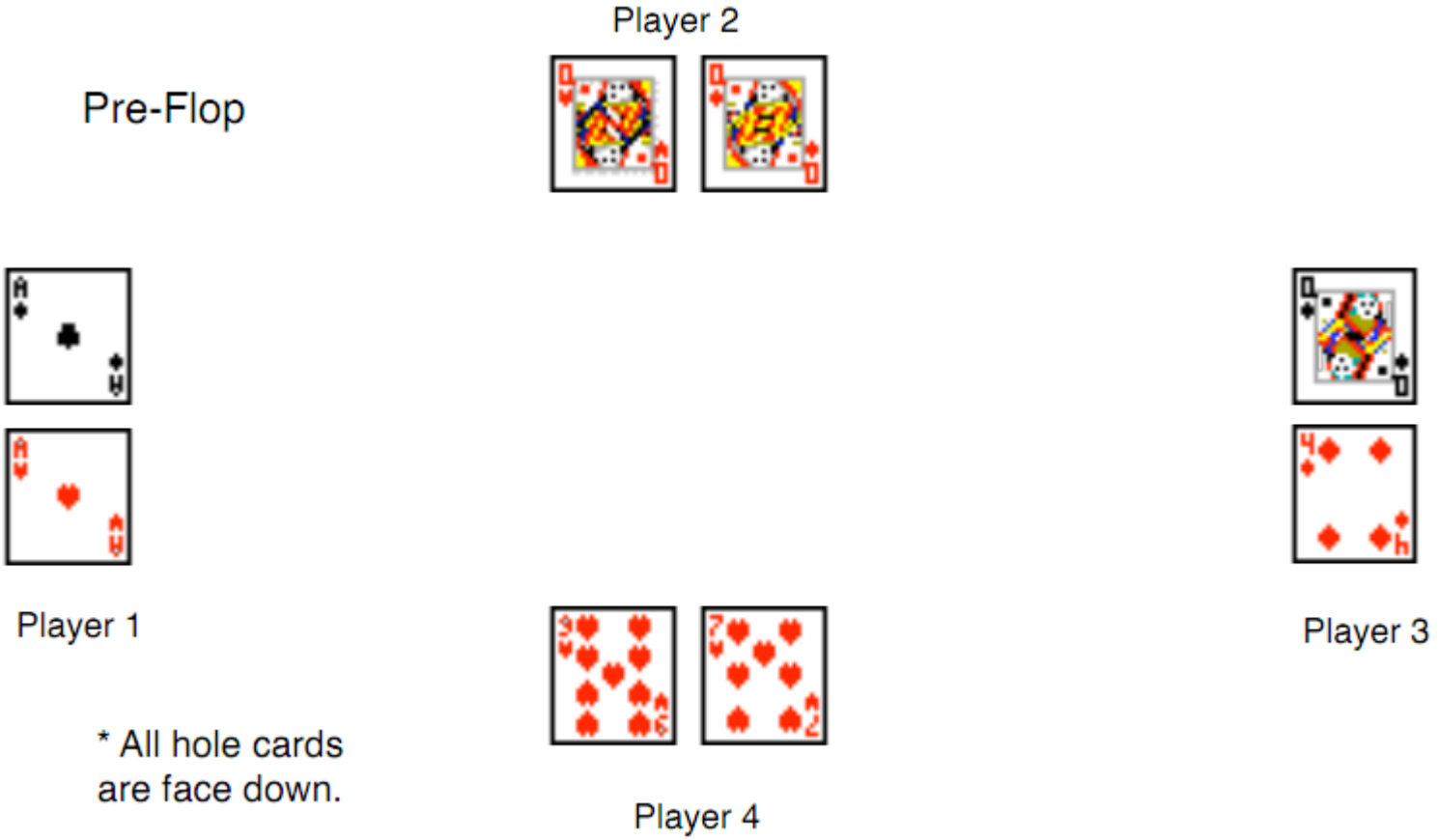
1. Two players post *blinds*



Source: Wikimedia Commons. URL: http://commons.wikimedia.org/wiki/File:Holdem_Table.png

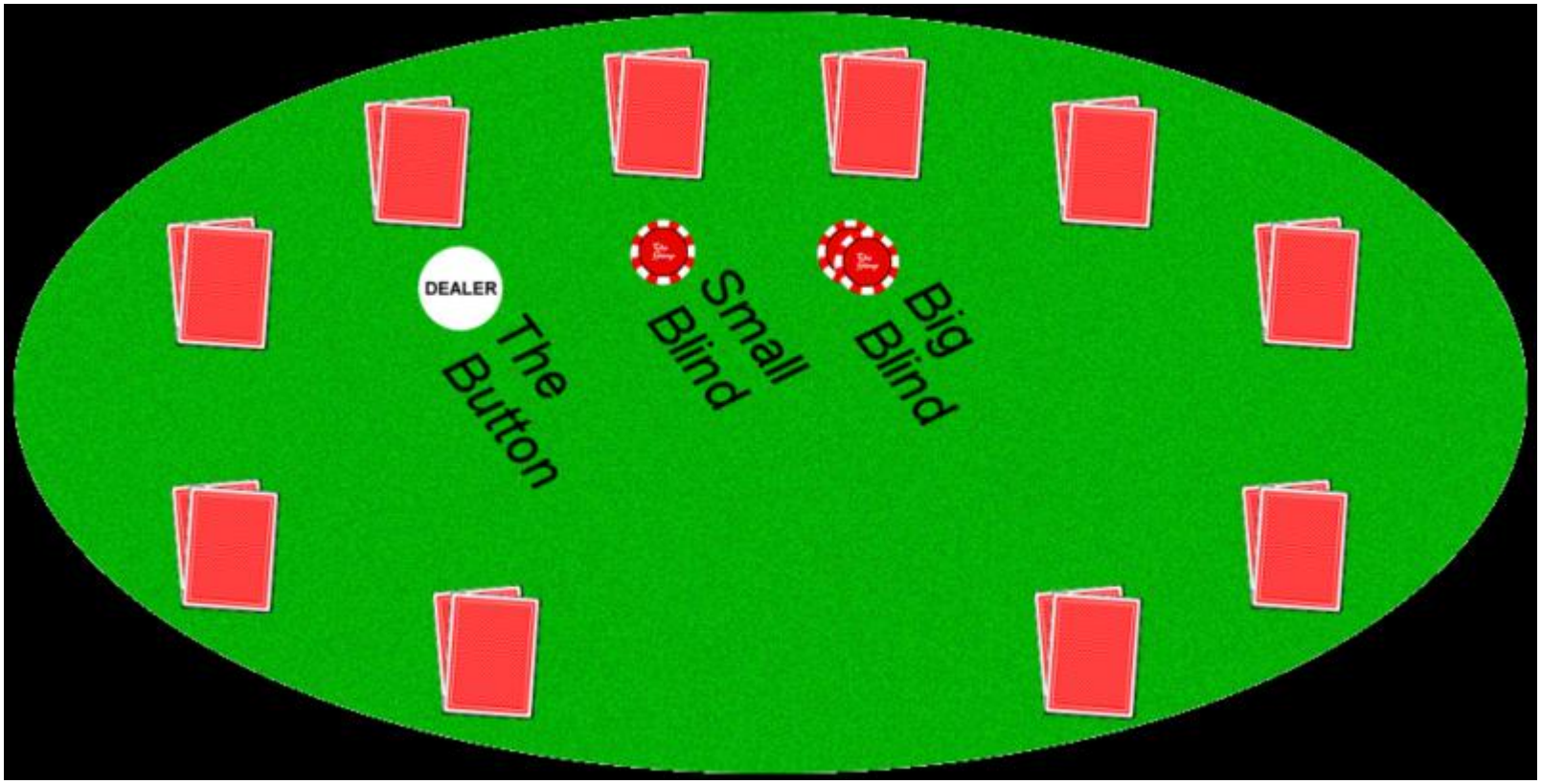
How a Hand is Played

- 2. *Hole cards* are dealt.



How a Hand is Played

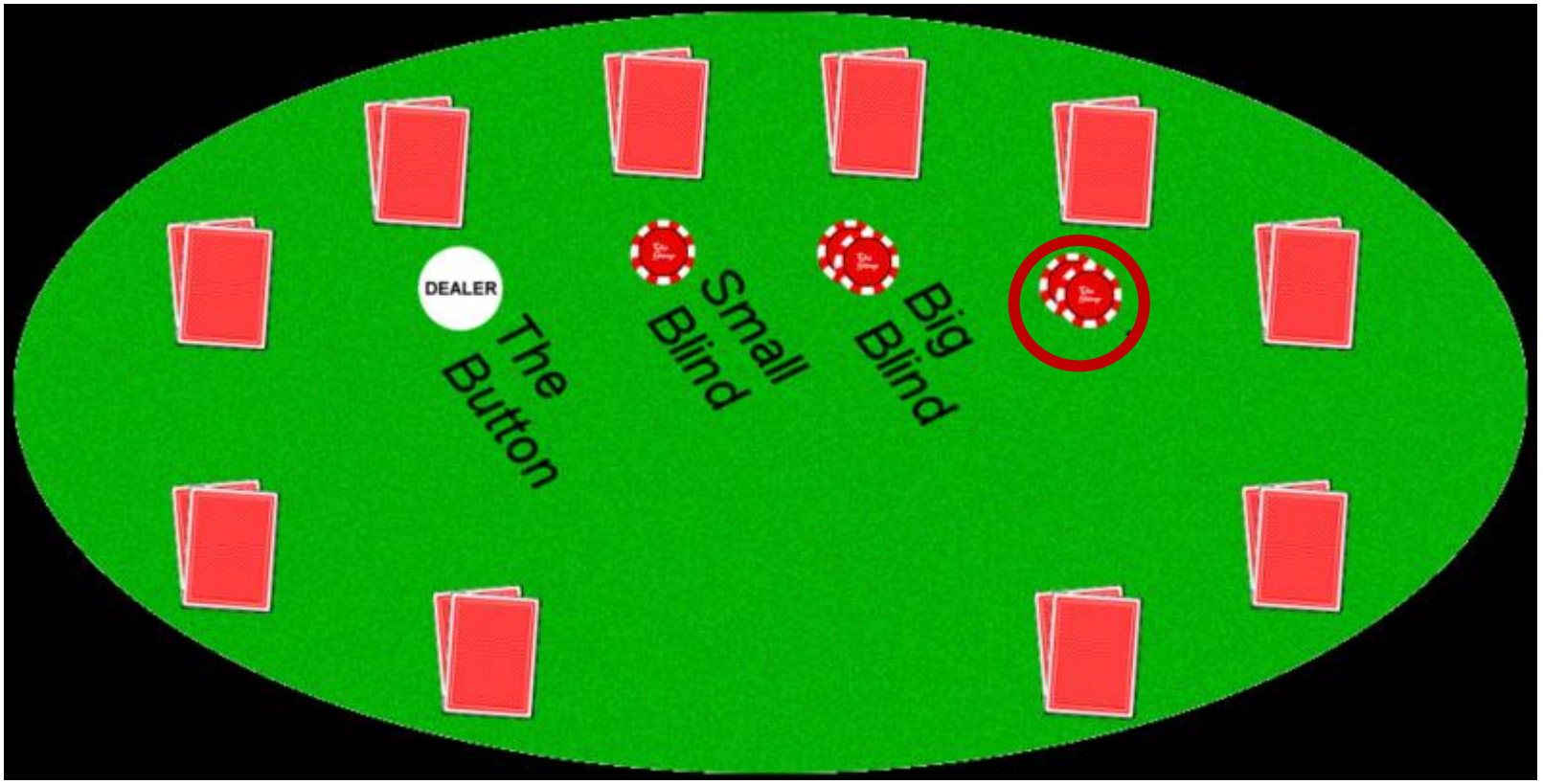
- 3. A round of betting is performed.



Source: Wikimedia Commons. URL: http://commons.wikimedia.org/wiki/File:Holdem_Table.png

Betting Actions: Calling

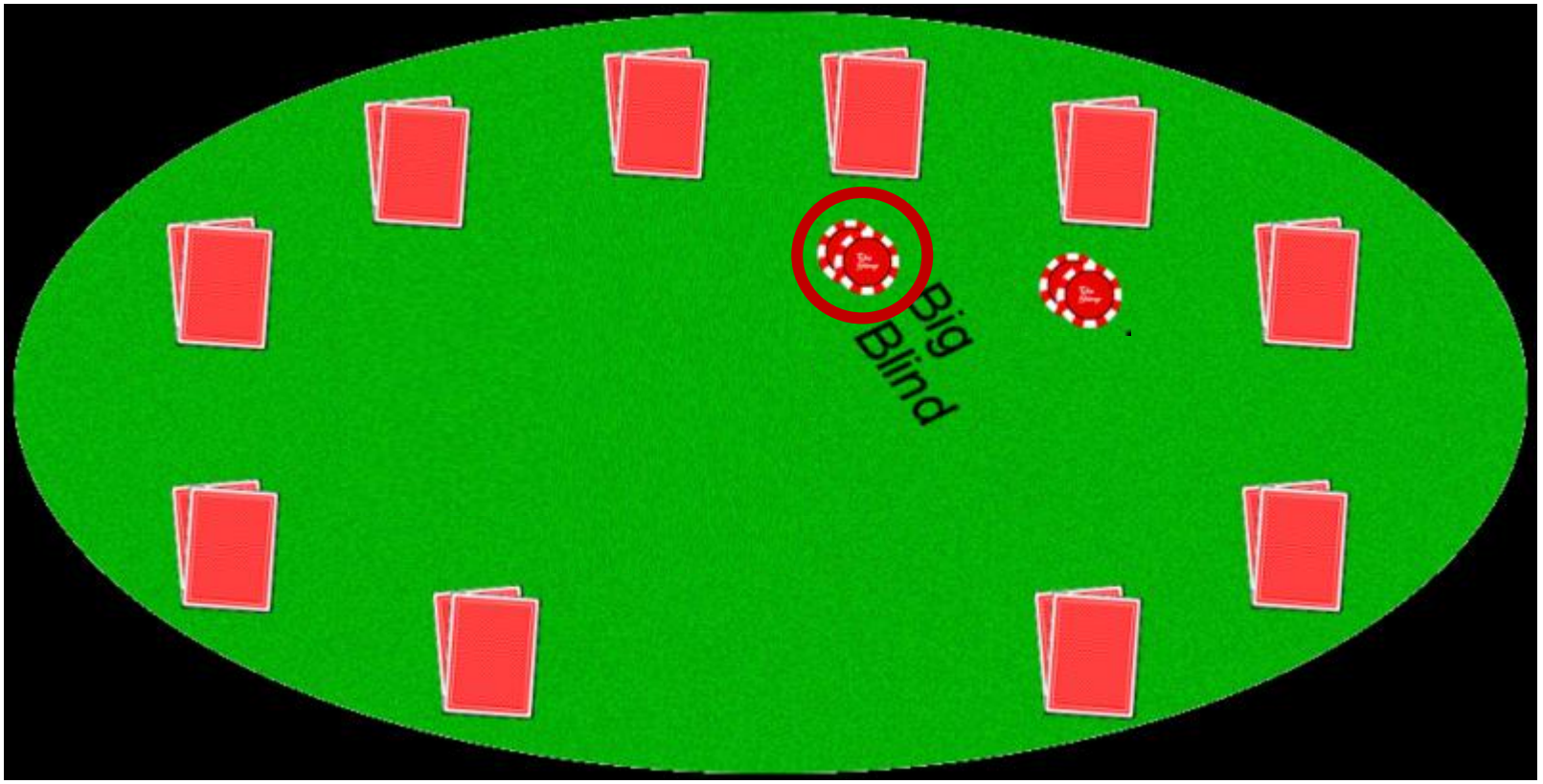
- Matches maximum bet.



Source: Wikimedia Commons. URL: http://commons.wikimedia.org/wiki/File:Holdem_Table.png

Betting Actions: Checking

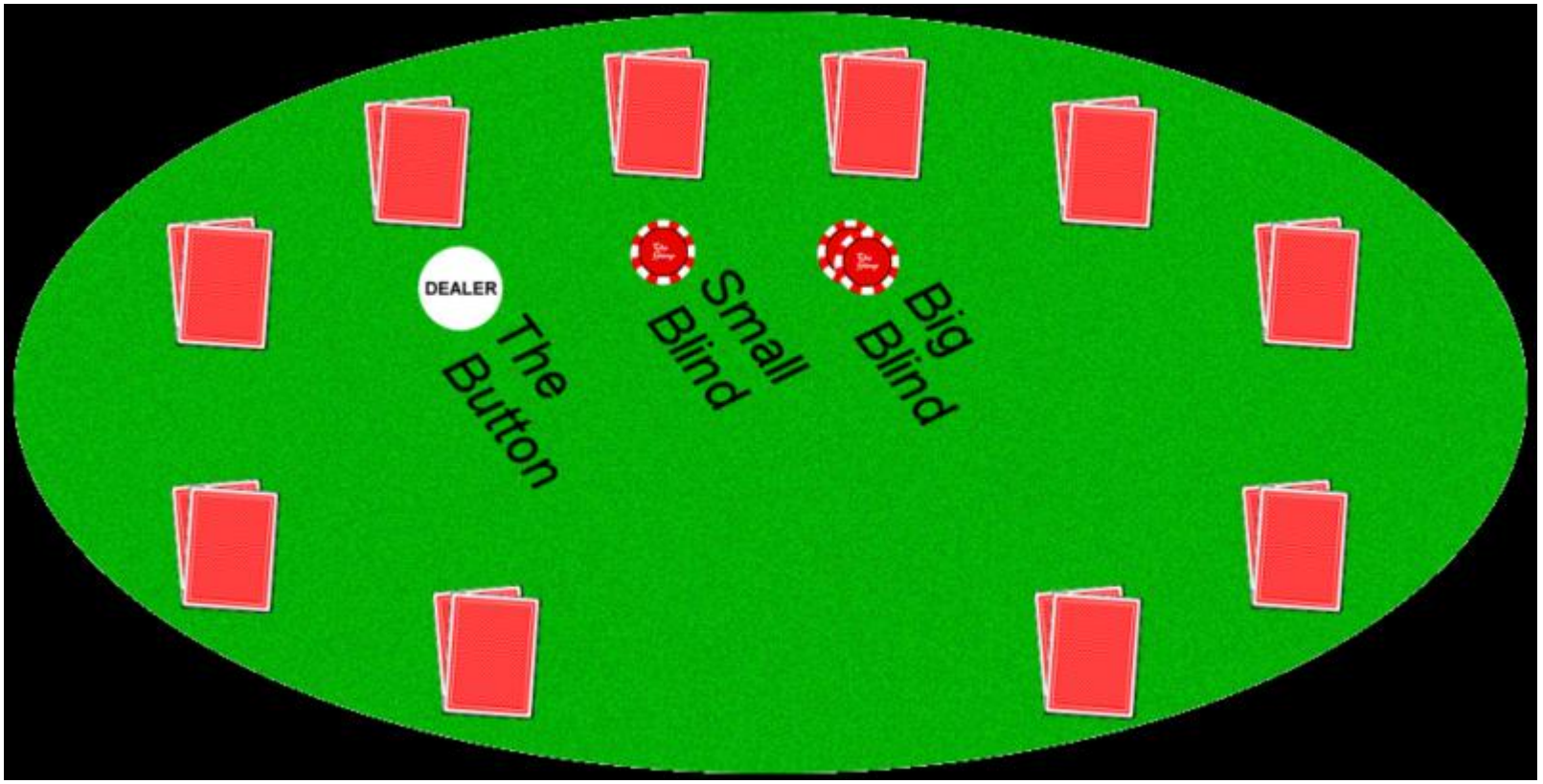
- Matches maximum bet.



Source: Wikimedia Commons. URL:
http://commons.wikimedia.org/wiki/File:Holdem_Table.png

Betting Actions: Folding

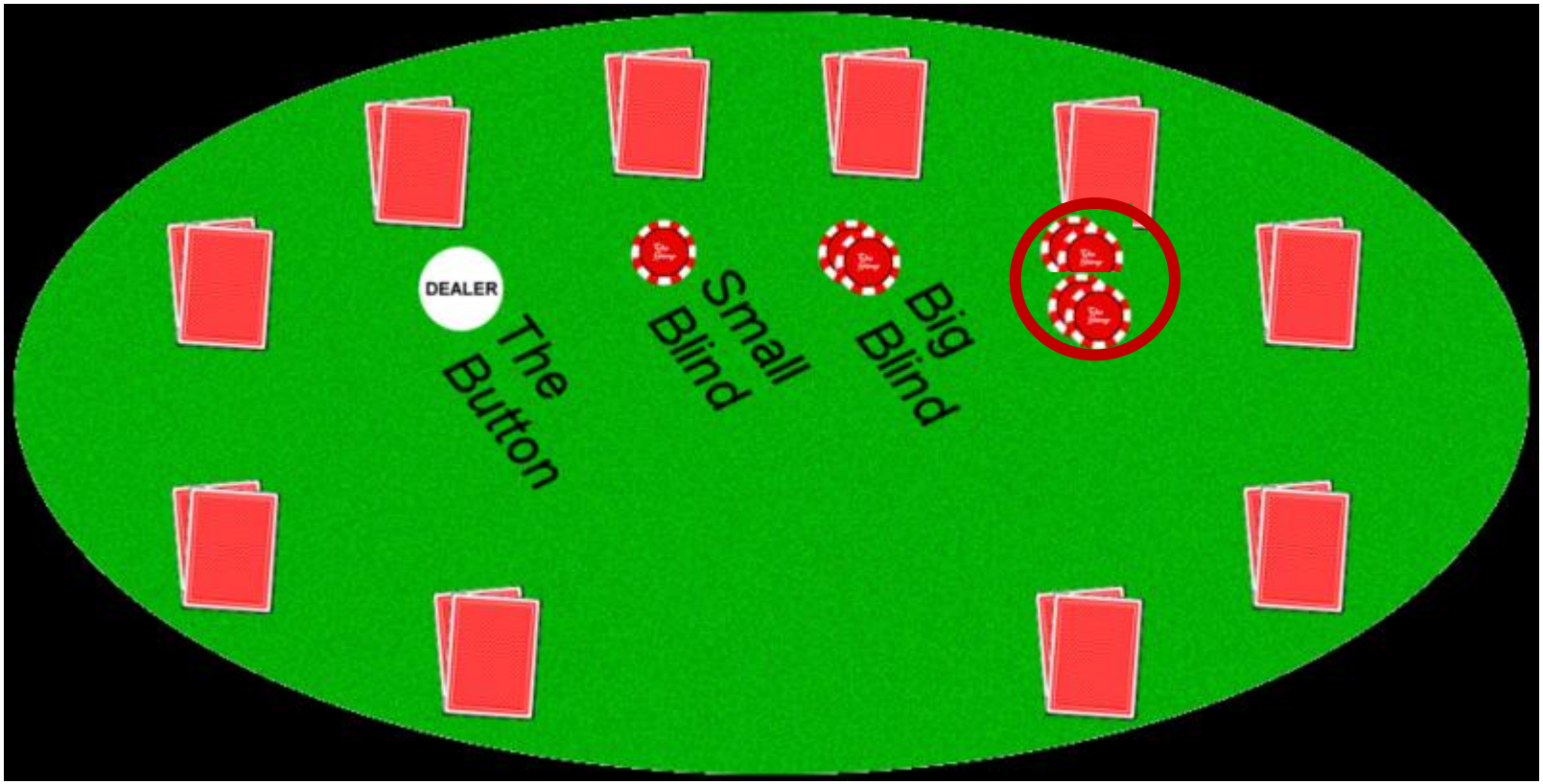
- Throw away cards, exit current round.



Source: Wikimedia Commons. URL: http://commons.wikimedia.org/wiki/File:Holdem_Table.png

Betting Actions: Raising / Betting

- Increases maximum bet.
- Wise to limit nr of re-raises.



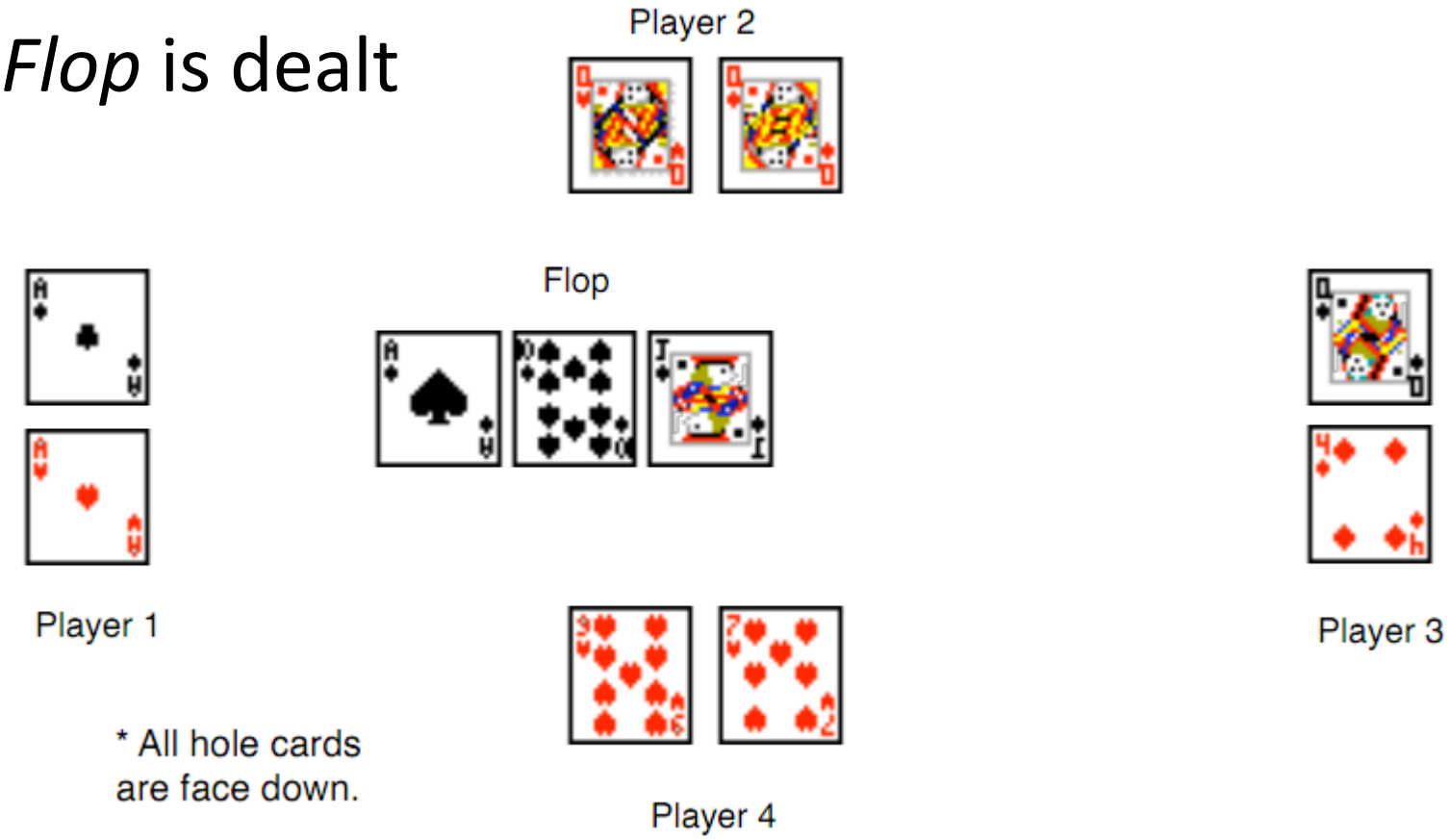
Source: Wikimedia Commons. URL: http://commons.wikimedia.org/wiki/File:Holdem_Table.png

Betting Actions

- Call or Check: Match highest bet so far
  - Example 1: I have bet 50, highest bet is 100. To *call*, I increase my bet by 50.
  - Example 2: I have bet 100, highest bet is 100. *Check* here means my bet is not increased.
- Fold: Quit the current hand, without further bets.
- Bet/raise: Increase current highest bet.
  - Example 1: I have bet 100, highest bet is 150. If I *raise* 50, I insert a total of a 100, raising my bet to 200.
  - Example 2: I am the first player (all bets are 0). I *bet* 100 and my bet is 100.

How a Hand is Played

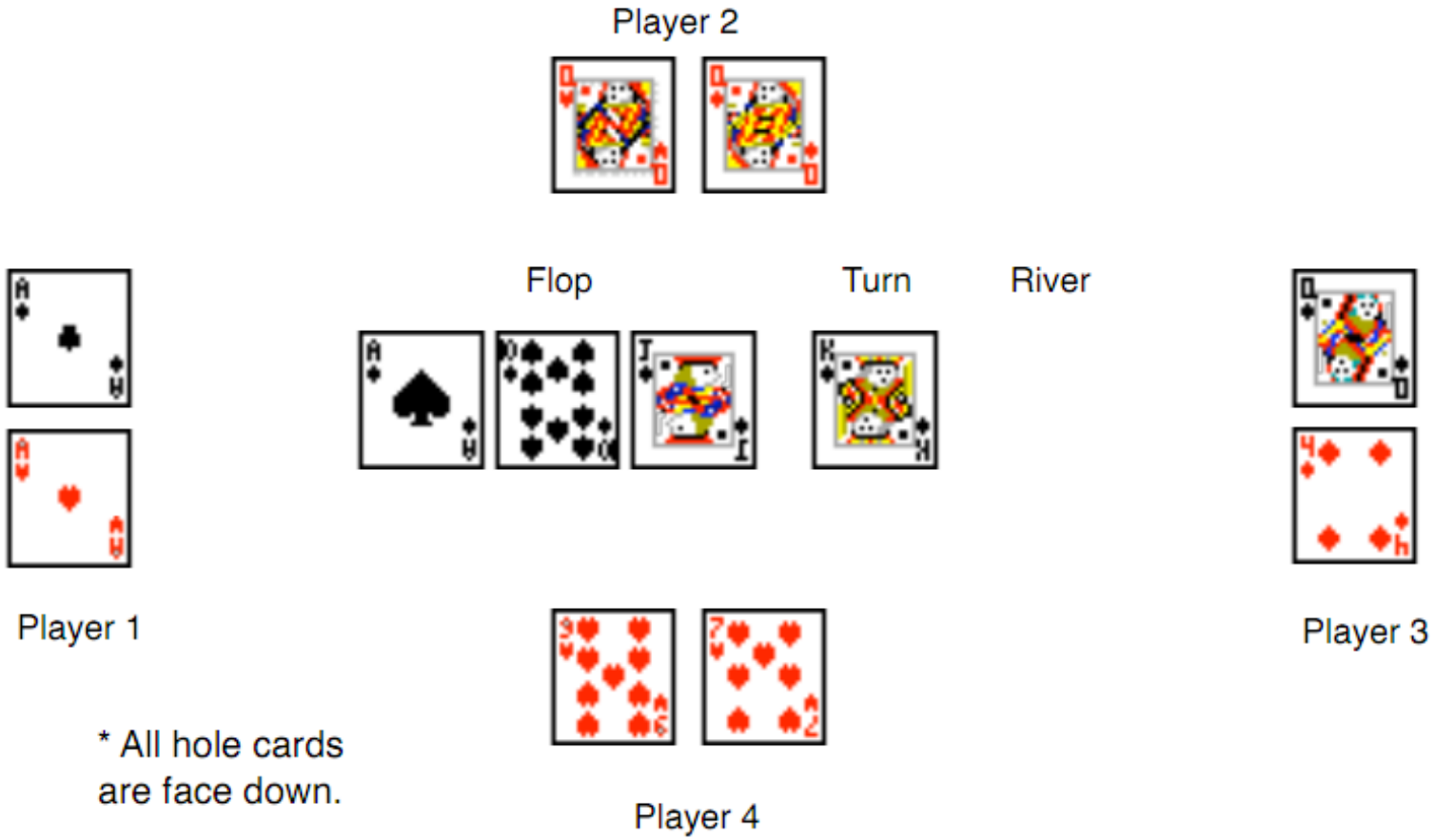
- 4. *Flop* is dealt



- 5. New round of betting

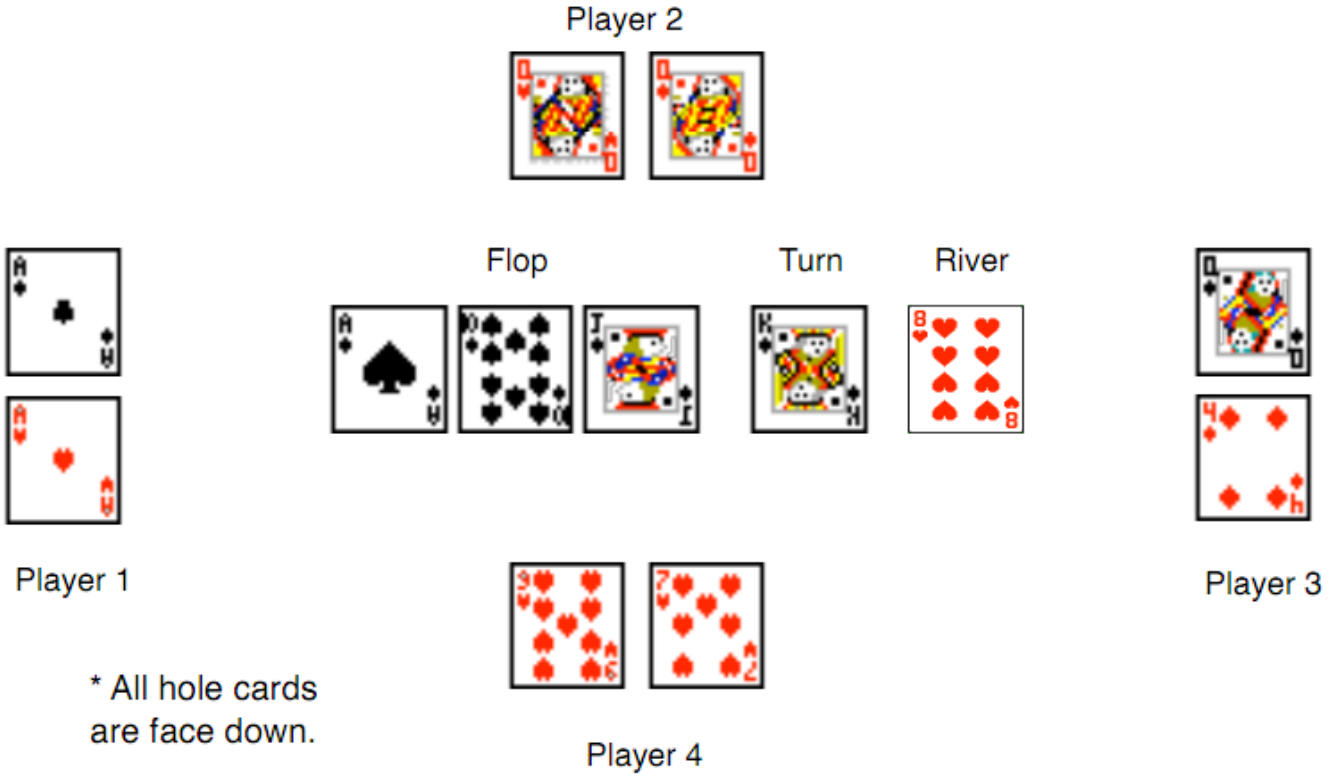
How a Hand is Played

- 6. *Turn* is dealt



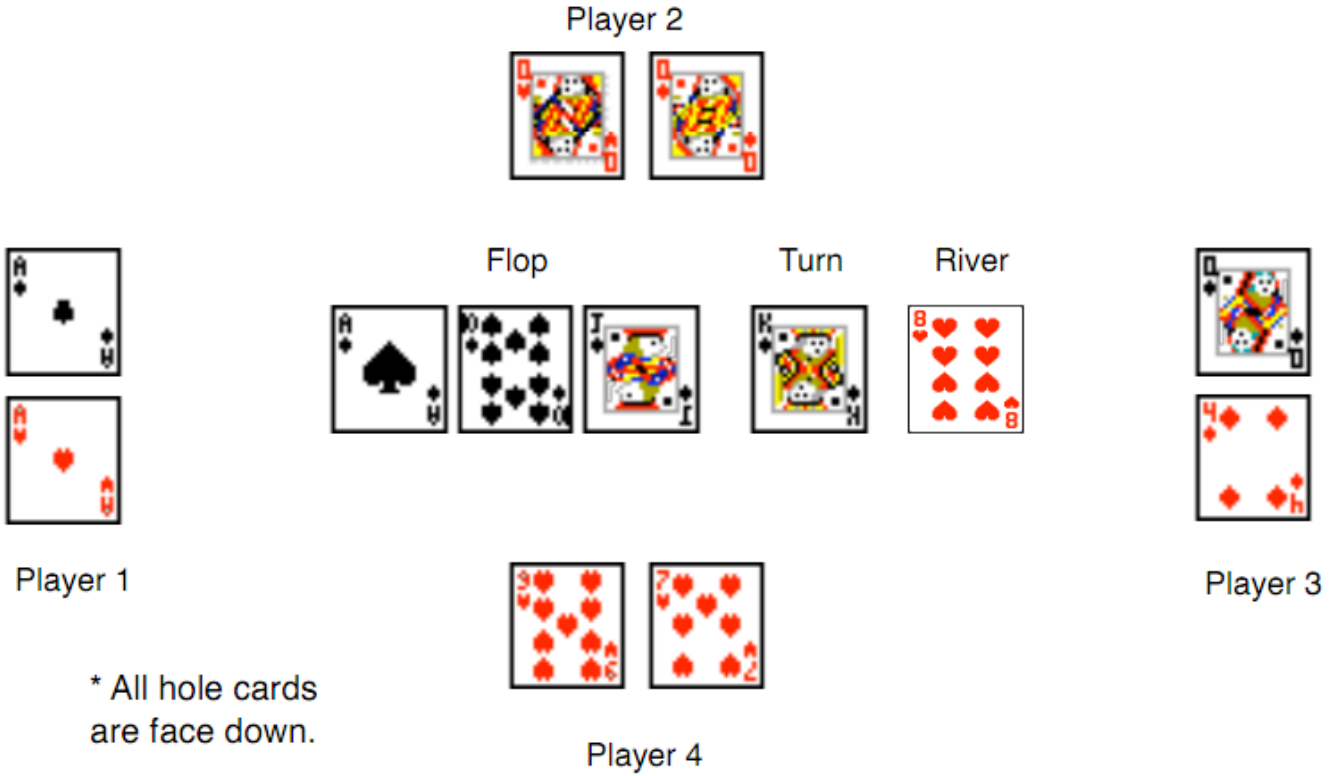
How a Hand is Played

- 7. New round of betting
- 8. *River* is dealt



How a Hand is Played

- 9. New round of betting
- 10. *Showdown*



- Tie-breaking:
  - Highest card
  - Kicker

Source: Wikimedia Commons. URL: http://commons.wikimedia.org/w/index.php?title=File:PokerHandRankings.pdf&page=1

Challenges

- From a hand of 6 or 7 cards, what is the best 5-card poker hand?
- How can we compare poker hands to determine a winner?
- We have some helping code for this:
  - http://www.idi.ntnu.no/emner/it3105/assignments/wrapper.php?path=code/cards.py

Power Rating

- A representation of hands that lets us compare their power easily.
- Suggestion:
  - Give all hand types a number 1-9:
    - 1 is nothing-hand (high card only)
    - 2 is one pair
    - And so on until: 9 is straight flush
  - Power rating is a sequence of this number followed by tie-braking information

POKER
HAND RANKINGS

Royal Flush	10♥ J♥ Q♥ K♥ A♥	[9, 14]
Straight Flush	4♣ 5♣ 6♣ 7♣ 8♣	[9, 8]
Four of a Kind	K♠ K♥ K♣ K♦ 3♠	[8, 13, 3]
Full House	10♥ 10♠ 10♦ A♠ A♣	[7, 10, 14]
Flush	10♠ K♠ 2♠ 6♠ 7♠	[6, 14, 10, 7, 6, 2]
Straight	7♣ 8♠ 9♦ 10♠ J♥	[5, 11]
Three of a Kind	5♠ 5♥ 5♣ J♦ A♦	[4, 5, 14, 11]
Two Pair	A♠ A♥ 3♣ 3♠ J♣	[3, 14, 3, 11]
One Pair	Q♦ Q♥ 2♥ 8♠ 9♣	[2, 12, 9, 8, 2]
High Card	A♠ Q♥ 2♥ 8♠ 9♣	= [1, 14, 12, 9, 8, 2]

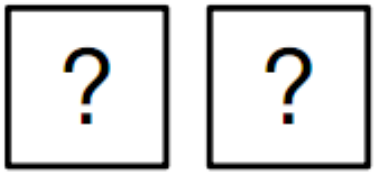
EVALUATING HANDS

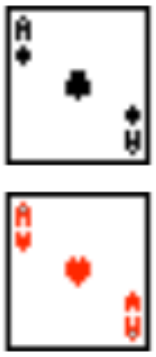
Source: Wikimedia Commons (By Thomas van de Weerd).
Url: http://commons.wikimedia.org/wiki/File:Texas_Hold_%27em_Hole_Cards.jpg?uselang=nb

Rollout Simuation

Roll-Out Perspective for Player 1

Player 2



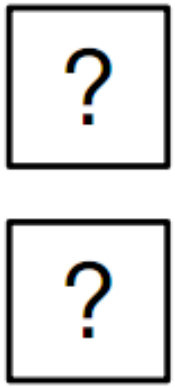


Player 1

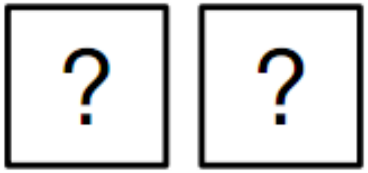
Flop

Turn

River



Player 3



Player 4

Rollout Simulation

Roll-Out Perspective for Player 2

Player 2

?

?

Player 1

Flop

Turn

River

?

?

?

Player 3

?

?

Player 4

Pre-Flop Rollouts

- Possible number of hole-card combinations:

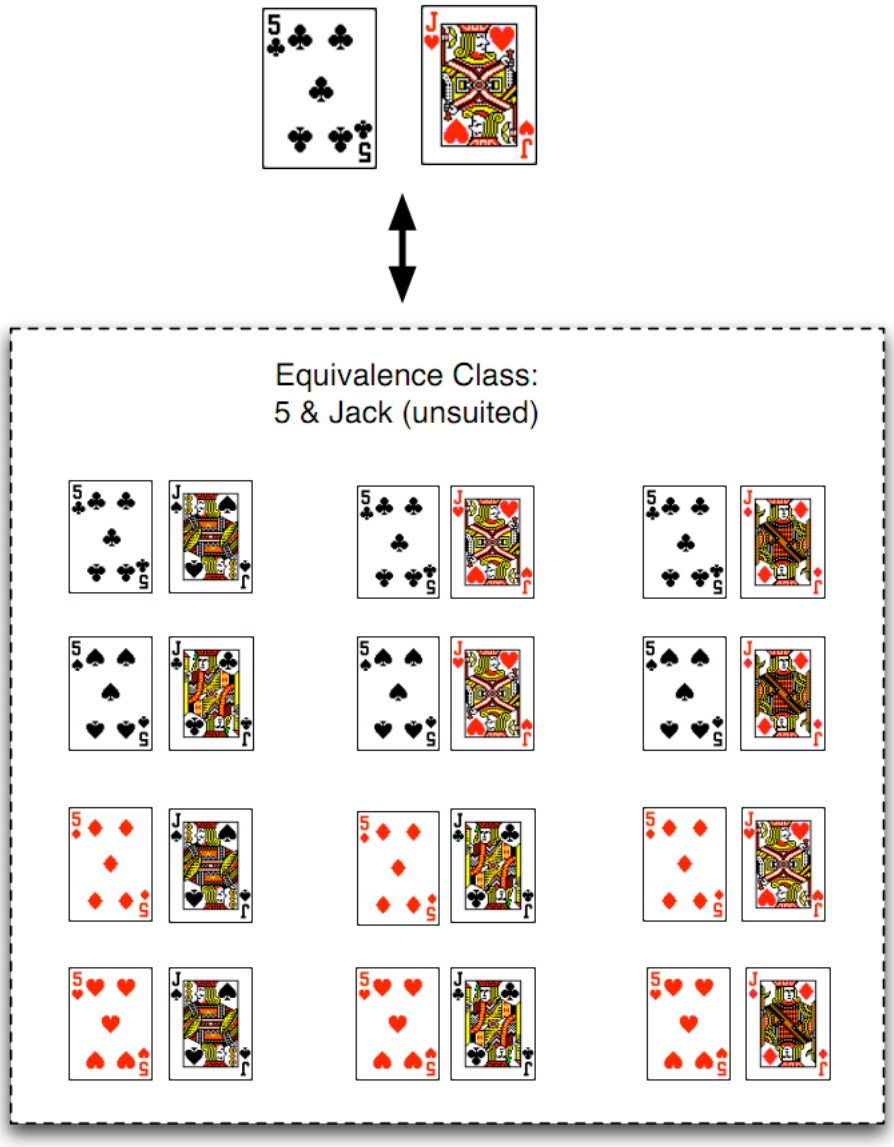
$$\binom{52}{2} = 1326$$

- We can do R rollout simulations for each combination, and each possible nr of players (2 to 10)
- R should be 1000-100.000
- S ~ 1326*10.000*9 ≈ 120 millions

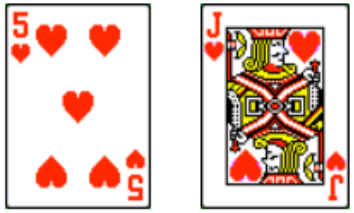
Equivalence Classes

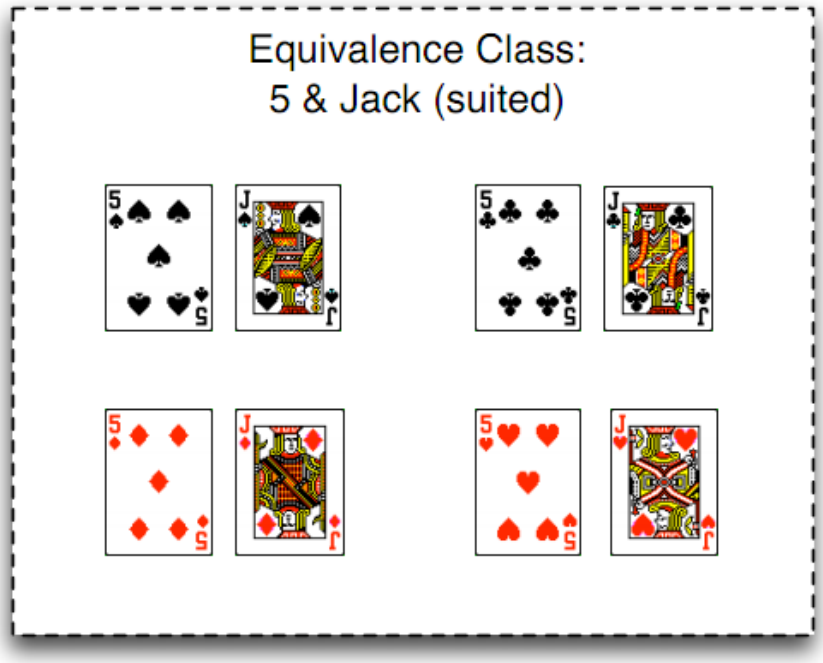
- Some hole card combinations have equal strength
- $(3\spadesuit, Q\clubsuit) = (3\clubsuit, Q\diamondsuit) = (3\diamondsuit, Q\clubsuit) = \ldots$
  - 12 *unsuited* combinations
- $(9\spadesuit, 10\spadesuit) = (9\clubsuit, 10\clubsuit) = (9\diamondsuit, 10\diamondsuit) = (9\heartsuit, 10\heartsuit)$
  - 4 *suited* combinations
- $(K\spadesuit, K\clubsuit) = (K\clubsuit, K\heartsuit) = (K\diamondsuit, K\heartsuit) = \ldots$
  - 6 *pair* combinations

Unsuited, Unpaired Equivalence Class

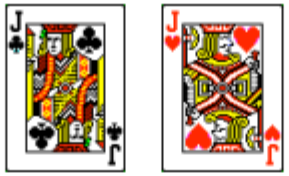


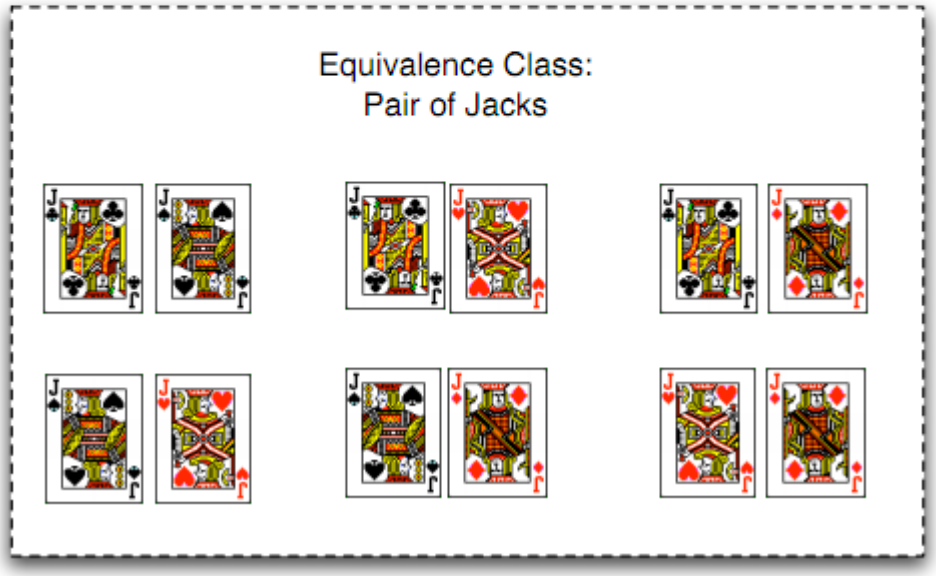
Suited Equivalence Class





Pair Equivalence Class





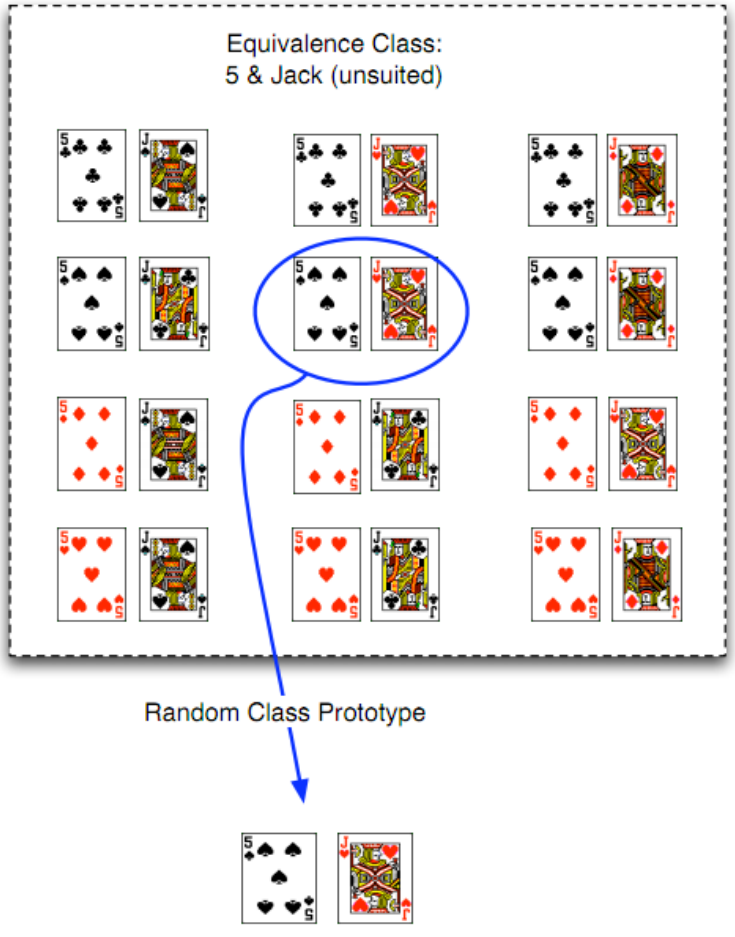
Equivalence Classes

- Total nr of equivalence classes:

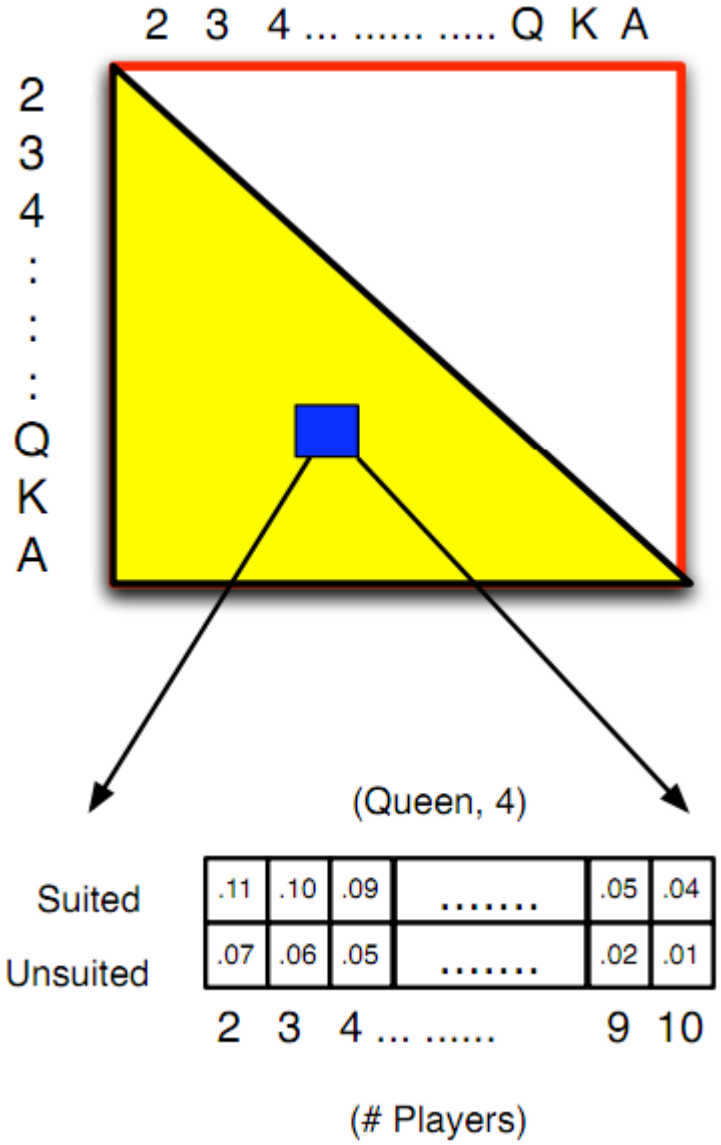
$$\binom{13}{2} + \binom{13}{2} + \binom{13}{1} = 78 + 78 + 13 = 169$$

- Total nr of simulations:

S ~ 169*10.000*9 ≈ 15 millions


Equivalence Class:
5 & Jack (unsuited)
Random Class Prototype
Do R
Rollout
Rounds
Wins
Ties
Losses
Income Rate
for class =
5&J (unsuited)
in a 4-player game

Equivalence Class Table

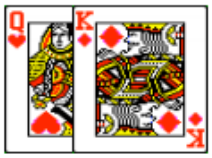


HAND STRENGTH

Source: Flickr (by beaumontpete)
URL: http://www.flickr.com/photos/beaumontpete/423640312/

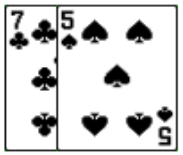
Hand strength

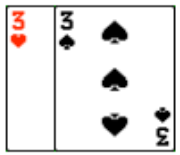
Missing Turn and/or River cards are NOT filled in during the basic hand-strength calculation.

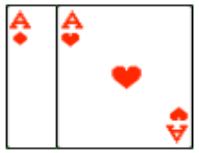


- vs -

$\binom{47}{2}$ possible pairs







$$\text{hand strength} = \left(\frac{Wins + \frac{Ties}{2}}{Wins + Ties + Losses} \right)^k$$

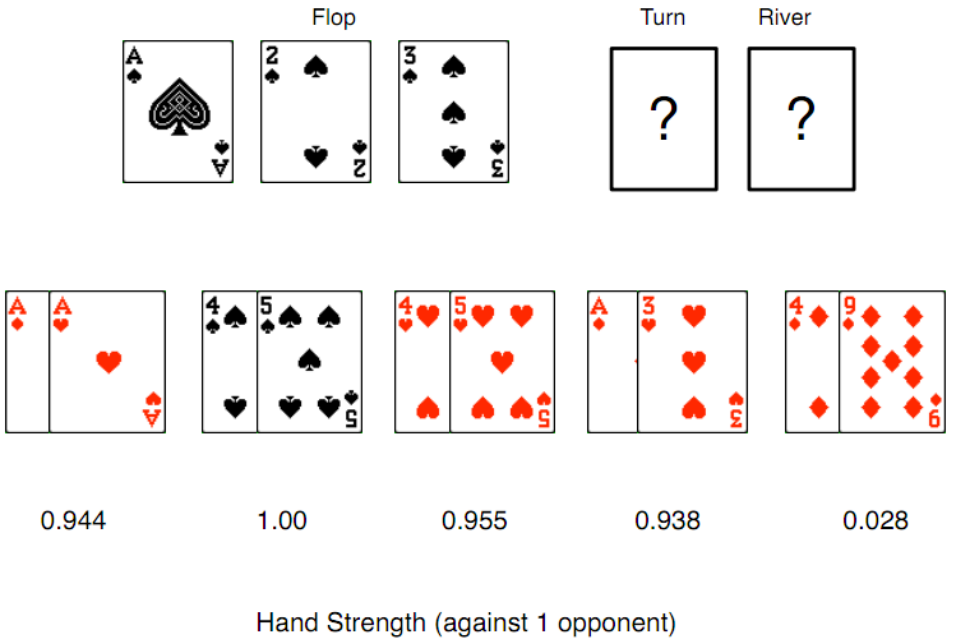
Hand Strength Example

- Suppose hole cards are A♢-Q♣
- Flop is J♡-4♣-3♡.
- Our hand rating is [1 14 12 13 4 3]
- $\binom{47}{2}$ = 1081 hands are available to opponents
- Comparing them all to ours:
  - 444 are better
  - 628 are worse
  - 9 are equal

Hand Strength Example

- $\text{hand strength} = \left(\frac{Wins + \frac{Ties}{2}}{Wins + Ties + Losses} \right)^k$
- Against 1 opponent:
  - Hand strength is 0.585^1
- Against 5 opponents:
  - Hand strength is $0.585^5 = 0.069$
- Limitations:
  - Hand strength assumes *all players* reach showdown
  - Does not consider possible turn and river cards

Hand Strength Development



Deciding on action

- Hand strength
- Pot odds
- Number of active opponents
- Number of raises
- Betting round (pre-flop, flop, turn, river)

- Opponent modelling

OPPONENT MODELLING

Source: Flickr (by Jim Sher)
URL: http://www.flickr.com/photos/blyzz/2545300865/in/phot