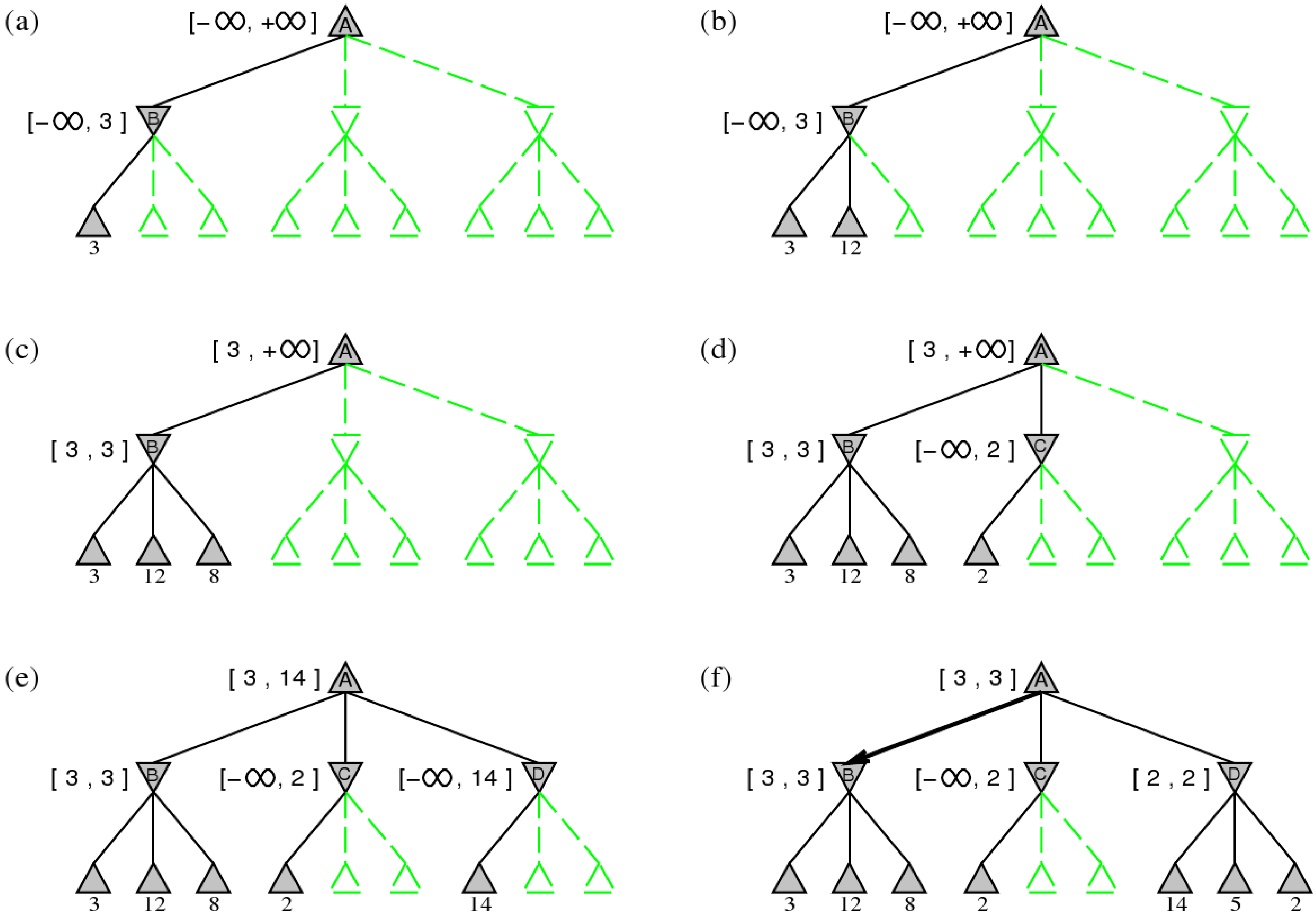
Two-players Games

Reminder and

- two-players games
- zero-sum games
- no chance nodes
- perfect information

- chess, checkers, ...

- note – the algorithms return a value, but we need a solution
- backup function


(a)
[−∞, +∞]
A
[−∞, 3]
B
3
(b)
[−∞, +∞]
A
[−∞, 3]
B
3
12
(c)
[3, +∞]
A
[3, 3]
B
3
12
8
(d)
[3, +∞]
A
[3, 3]
B
[−∞, 2]
C
3
12
8
2
(e)
[3, 14]
A
[3, 3]
B
[−∞, 2]
C
[−∞, 14]
D
3
12
8
2
14
(f)
[3, 3]
A
[3, 3]
B
[−∞, 2]
C
[2, 2]
D
3
12
8
2
14
5
2

Reminder (2)

- **function** alphabeta(node, depth, α, β, Player)
-     **if** (depth = 0 or node is a terminal node) **return** the heuristic value of node
-     **if** (Player = MaxPlayer)
-         **for each** child of node
-             α := max(α, alphabeta(child, depth-1, α, β, not(Player)))
-             **if** (β≤α) break
-         **return** α
-     **else**
-         **for each** child of node
-             β := min(β, alphabeta(child, depth-1, α, β, not(Player)))
-             **if** (β≤α)   break
-         **return** β

Step 1 - Negamax

- **function** negamax(node, depth, α, β, color)
- **if** (depth = 0 or node is a terminal node) **return** the heuristic value of node
- **if** (Player = MaxPlayer)
- **for each** child of node
- α := max(α, -negamax(child, depth-1, -β, -α, -color))
- **if** (β≤α) break
- **return** α
- **else**
- **for each** child of node
- β := min(β, alphabeta(child, depth-1, α, β, not(Player)))
- **if** (β≤α) break
- **return** β

Step 2 – Aspiration Search

- $[\alpha, \beta]$ interval – window
- alphabeta initialization $[-\infty, +\infty]$
- what if we use $[\alpha_0, \beta_0]$
  - x = alphabeta(node, depth, α_0, β_0,player)
  - $\alpha_0 \leq x \leq \beta_0$ - we found a solution
  - $x \leq \alpha_0$ - failing low (run again with $[-\infty, x]$)
  - $x \geq \beta_0$ - failing high (run again with $[x, +\infty]$)

Step 3 – Scout – Idea

- assume we are in a MAX node
- we are about to search a child 'c'
- we already have obtained a lower bound 'α'

- Is it worth searching the branch 'c'?

- we need to have some test ...

Step 3 – Scout – A Test

- what we really need at that moment is a bound (not the precise value)
- Remember Aspiration Search?
  - $x \leq \alpha_0$ - failing low (we know, that solution is $\leq x$)
  - $x \geq \beta_0$ - failing high (we know, that solution is $\geq x$)
- What if we use a null-window $[\alpha, \alpha+1]$ (or $[\alpha,\alpha]$)?
  - we obtain a bound …

Step 3 – NegaScout

function negascout(node, depth, α, β, color)

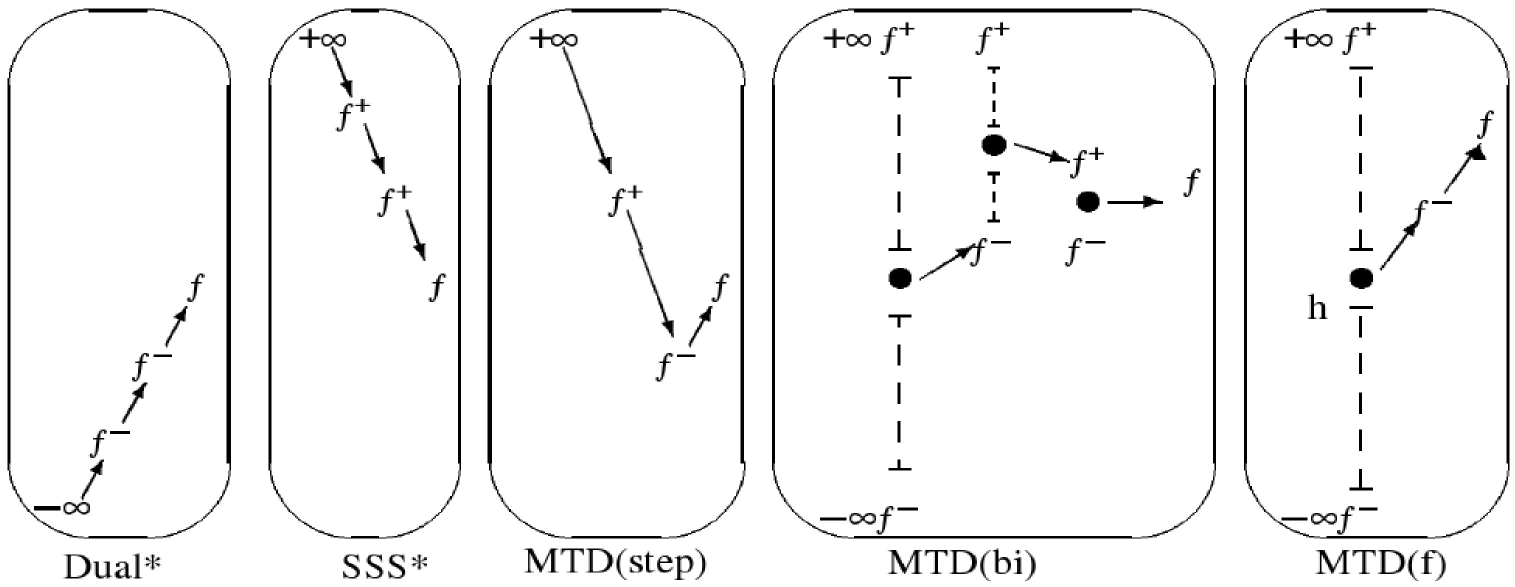
- **if** ((depth = 0) or (node is a terminal node)) **return** eval(node)
- b := β
- **for each** child of node
- v := -negascout(child, depth-1, -b, -α, -color))
- **if** ((α < v < β) and (child is not the first child))
- v := -negascout(child, depth-1, -β, -α, -color))
- α := max(α, v)
- **if** (β≤α) break
- b := α + 1
- **return** α

Step 3 – NegaScout

- also termed Principal Variation Search (PVS)
- dominates alphabeta (never evaluates more nodes than alphabeta)
- depends on the move ordering
- can benefit from transposition tables
- generally 10-20% faster compared to alpha-beta

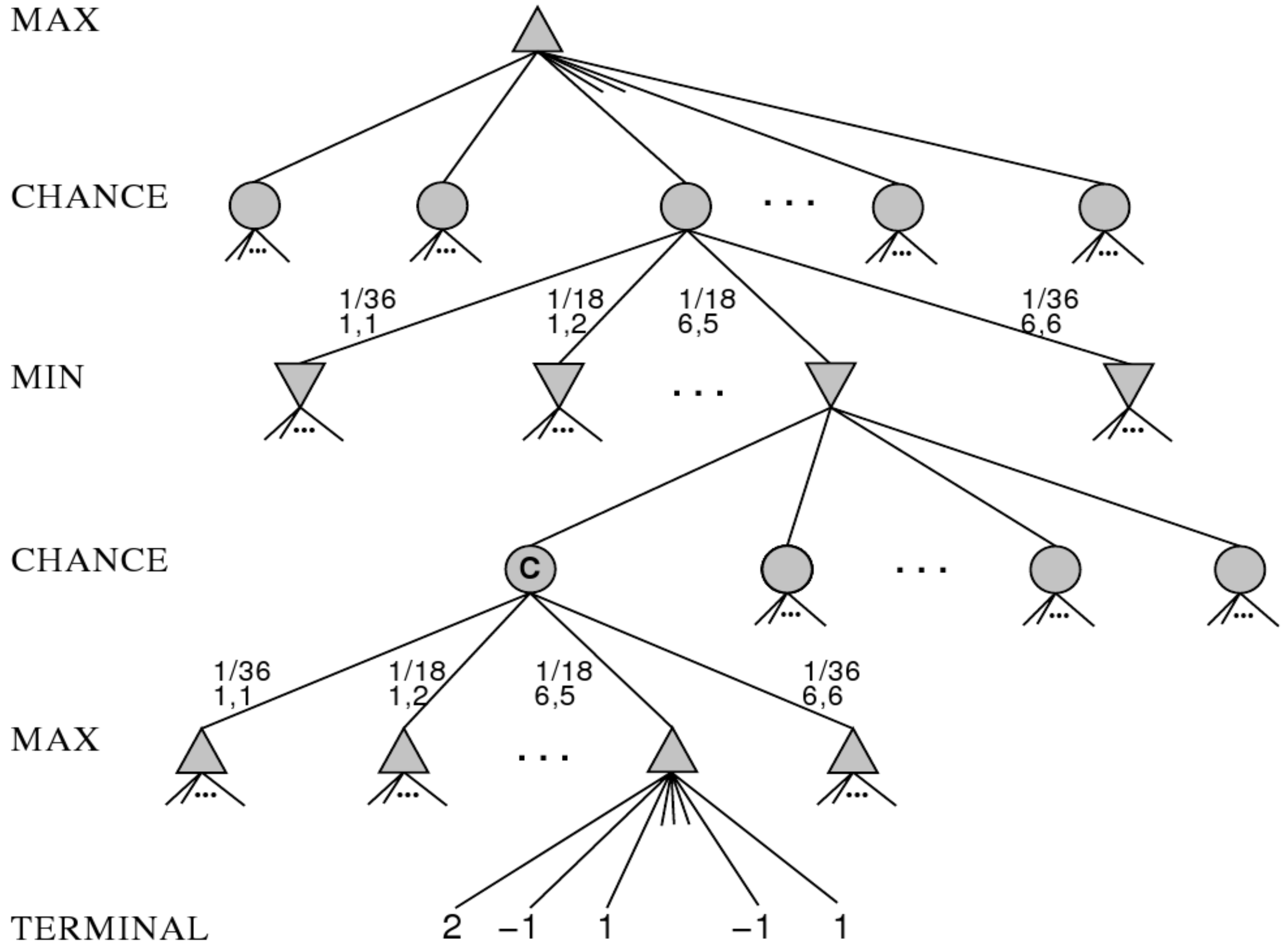
Step 4 – MTD

- Memory-enhanced Test Driver

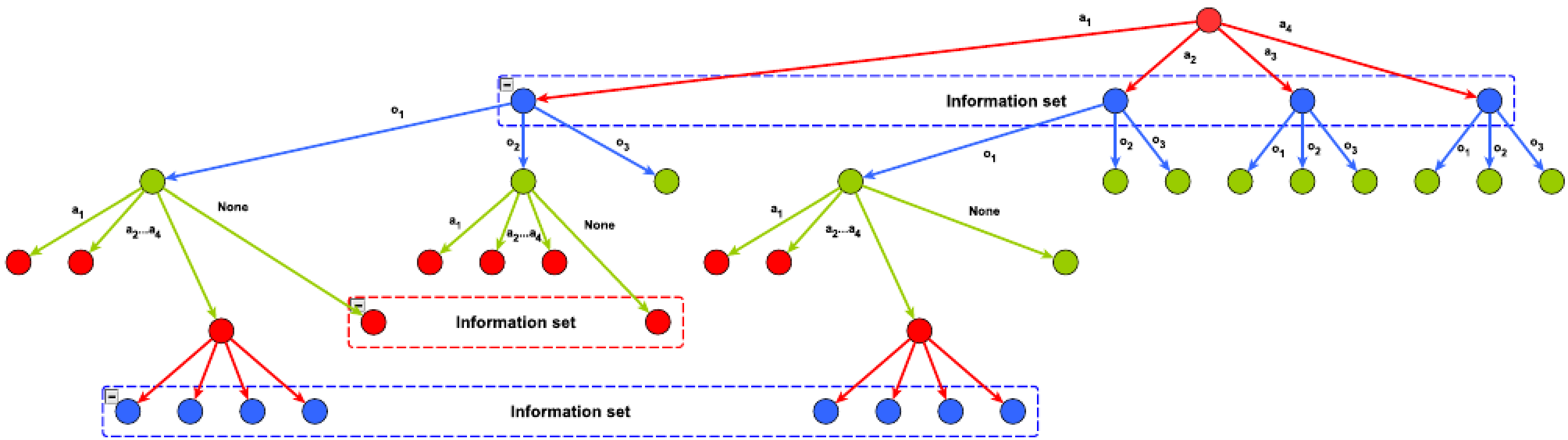


- Best-first fixed-depth minimax algorithms. Plaat et. al. , In *Artificial Intelligence,* Volume 87, Issues 1-2, November 1996, Pages 255-293

Other Games - Chance nodes



Other Games – Imperfect Information



Games and AI

- checkers – 1994 Chinook ... now a solved game (the program cannot loose)
- chess – 1997 Deep Blue, …, computers are now too strong
- go – best human players are still undefeated, but … (see http://www.computer-go.info/h-c/index.html)
- poker – 2008 best program (Polaris) can beat a human master
- … and many, many others (Hex, Havannah, ...)

- University of Alberta
- Computer Olympiad

Challenges?

- simultaneous moves, imperfect information
- durative moves (asynchronous chess, Google AI Challenge, ...)
- General Game Playing
  - an algorithm receives rules of the game and has to play
- ARIMAA (created in 2002)
  - BF ≈ 17,000; no opening books; very few patterns
  - easy for people, very difficult for an algorithm
- using a 'real-AI-algorithms' in computer video-games
  - very few examples: F.E.A.R., World In Conflict, ...