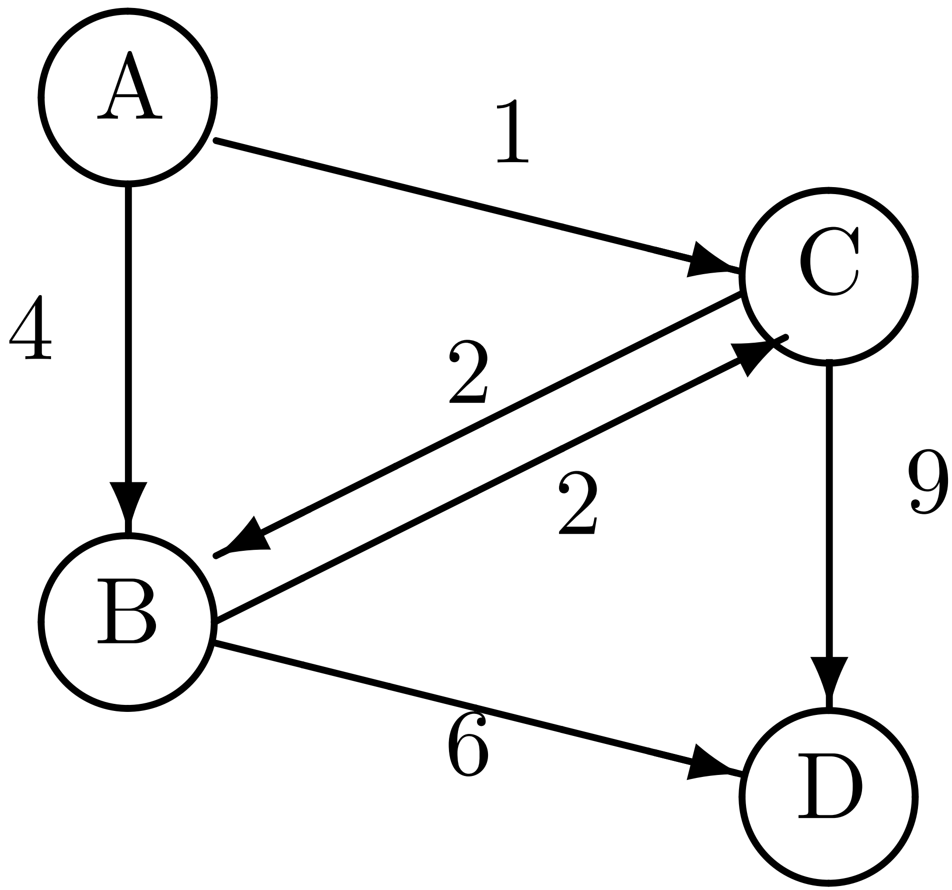
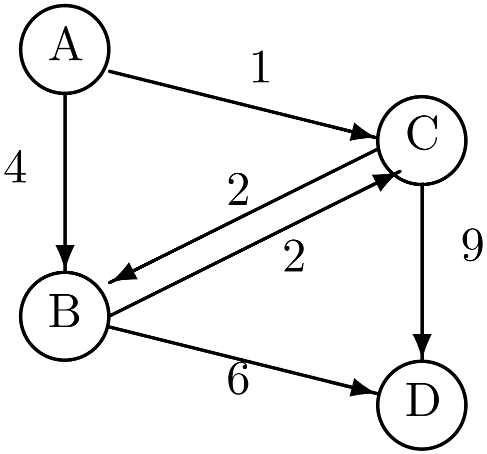
A* Example



$$h(A) = 8$$
$$h(B) = 3$$
$$h(C) = 7$$
$$h(D) = 0$$

START = A
GOAL = D

A* Example



$$h(A) = 8$$
$$h(B) = 3$$
$$h(C) = 7$$
$$h(D) = 0$$

- This heuristic is admissible

START = A

GOAL = D

h*(A) = 9
h*(B) = 6
h*(C) = 8
h*(D) = 0

A* with cycle checking

OPEN:

1. 8 {<A> (g-val+h-val=f-val)} == {<A> (0+8= 8)}
2. 7 {<A,B> (4+3=7), <A,C> (1+7=8)}
3. 8 {<A,C> (1+7=8), <A,B,D> (10+0=10)}
4. 6 {<A,C,B> (3+3=6), <A,B,D> (10+0=10), <A,B,C> (6+7=13)}
5. 9 {<A,C,B,D> (9+0=9), <A,B,D> (10+0=10), <A,B,C> (6+7=13)}
6. Return solution path <A,C,B,D>

Sequence of f-values of the paths-expanded.
8, 7, 8, 6, 9

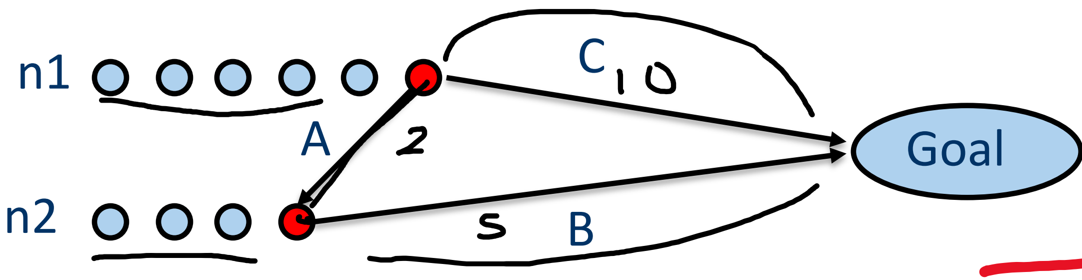
Proposition 2 (slide 139) A* with an admissible heuristic never expands a node with f-value greater than C* (the cost of an optimal solution)

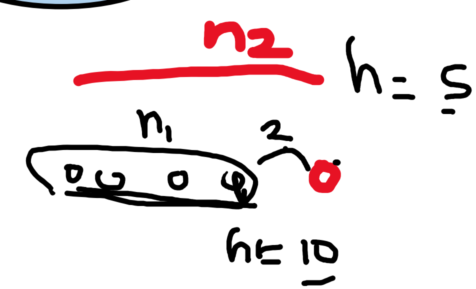
At every stage some prefix of an optimal path is on OPEN

Monotone Heuristics

- For all paths n1 and n2 and all actions a:

  $h(n1) \leq C(n1.final(), a, n2.final()) + h(n2)$





A = C(n1.final(), a, n2.final())

B = h(n2)

C = h(n1)

Triangle inequality

Consequences of monotonicity

1. The sequence of f-values of the paths expanded by A* is non-decreasing. That is, if n_2 is expanded **after** n_1 by A* then f(n1) ≤ f(n2). (Not necessarily true for an admissible heuristic as that heuristic might be non-monotone)
2. With a monotone heuristic, the first time A* expands a path **n =** $<s_0, ..., s_n>$ that reaches the state s_n, **n** must be a minimum cost path to s_n

A* with cycle checking

OPEN:

1. 8 {<A> (g-val+h-val=f-val)} == {<A> (0+8= 8)}
2. 7 {<A,B> (4+3=7), <A,C> (1+7=8)}
3. 8 {<A,C> (1+7=8), <A,B,D> (10+0=10)}
4. 6 {<A,C,B> (3+3=6), <A,B,D> (10+0=10), <A,B,C> (6+7=13)}
5. 9 {<A,C,B,D> (9+0=9), <A,B,D> (10+0=10), <A,B,C> (6+7=13)}
6. Return solution path <A,C,B,D>

Sequence of f-values of the paths-expanded.
8, 7, 8, 6, 9

Not non-decreasing ($f(x_i) \leq f(x_{i+1})$ for all i)

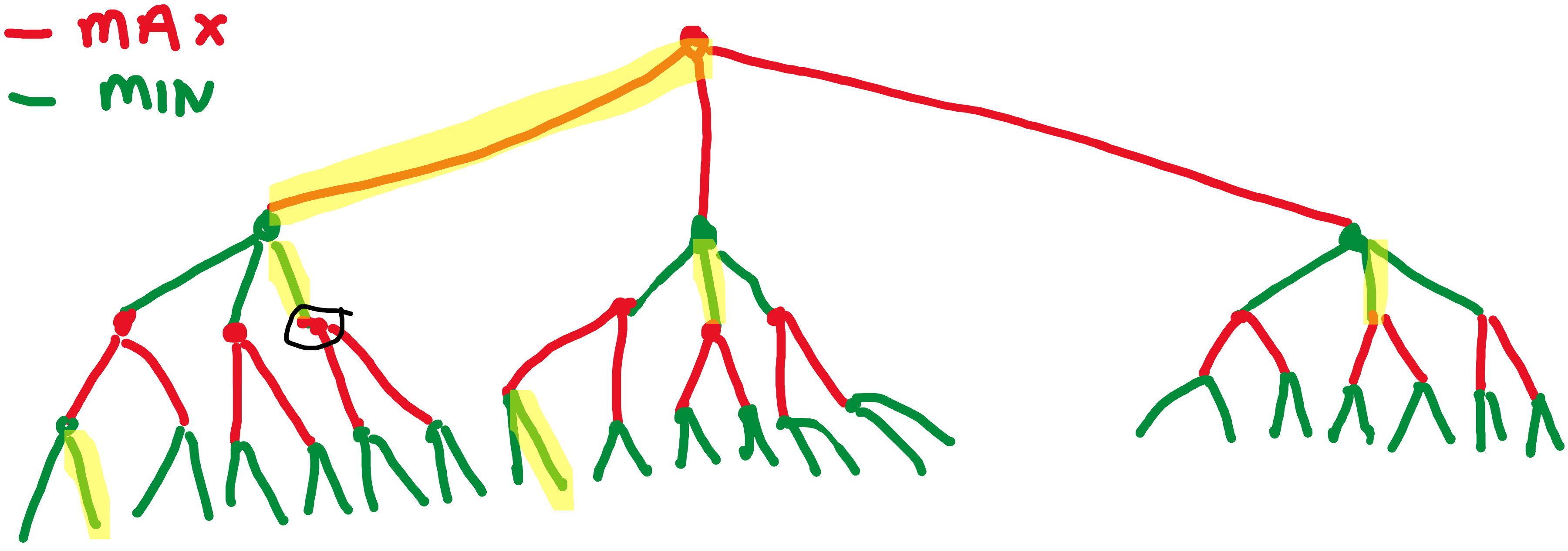
A* with cycle checking

OPEN:

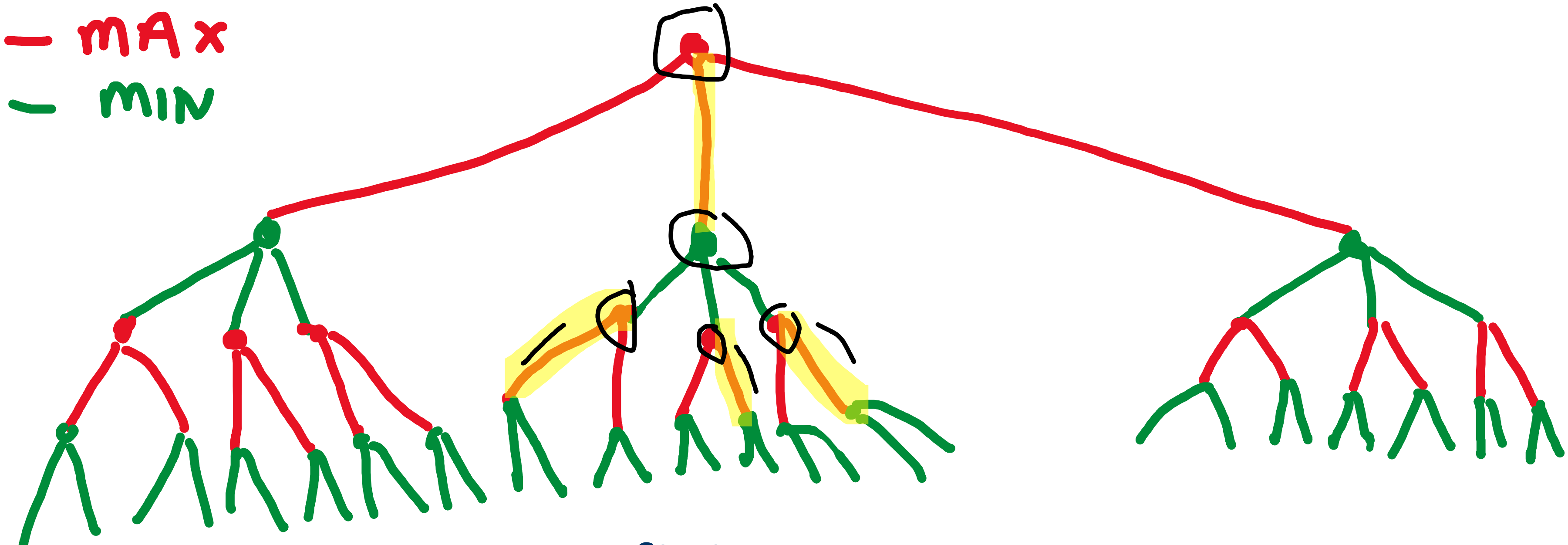
1. 8 {<A> (g-val+h-val=f-val)} == {<A> (0+8= 8)}
2. 7 {<A,B> (4+3=7), <A,C> (1+7=8)}
3. 8 {<A,C> (1+7=8), <A,B,D> (10+0=10)}
4. 6 {<A,C,B> (3+3=6), <A,B,D> (10+0=10), <A,B,C> (6+7=13)}
5. 9 {<A,C,B,D> (9+0=9), <A,B,D> (10+0=10), <A,B,C> (6+7=13)}
6. Return solution path <A,C,B,D>

First path expanded that reaches B

Game Trees



Game Trees

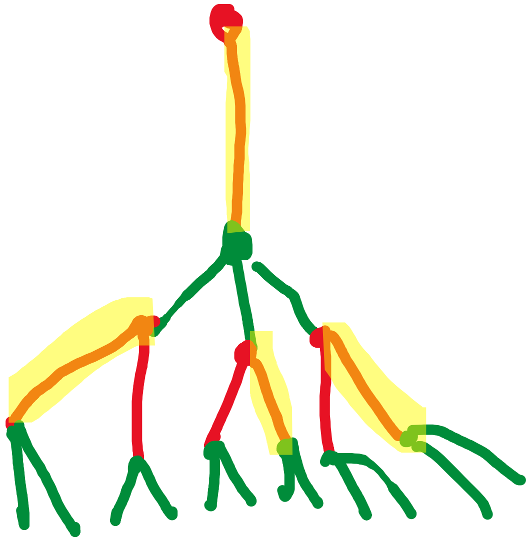


Strategy

Game Trees

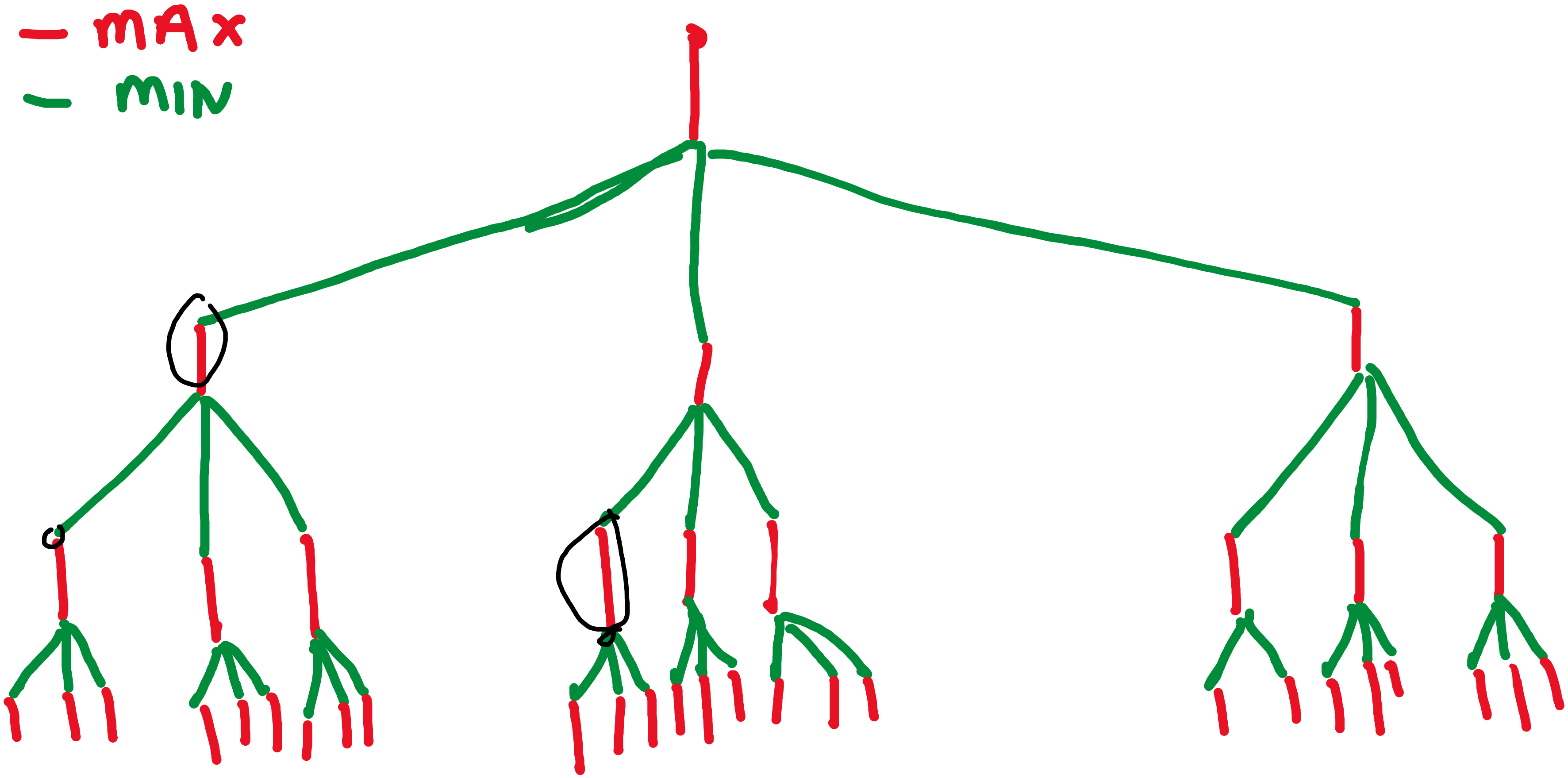
– MAX

– MIN



Strategy

Game Trees



Strategy