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Professor McMahon
CS440 Intro to AI
March 27, 2020

1a. Minimax, an exhaustive algorithm.
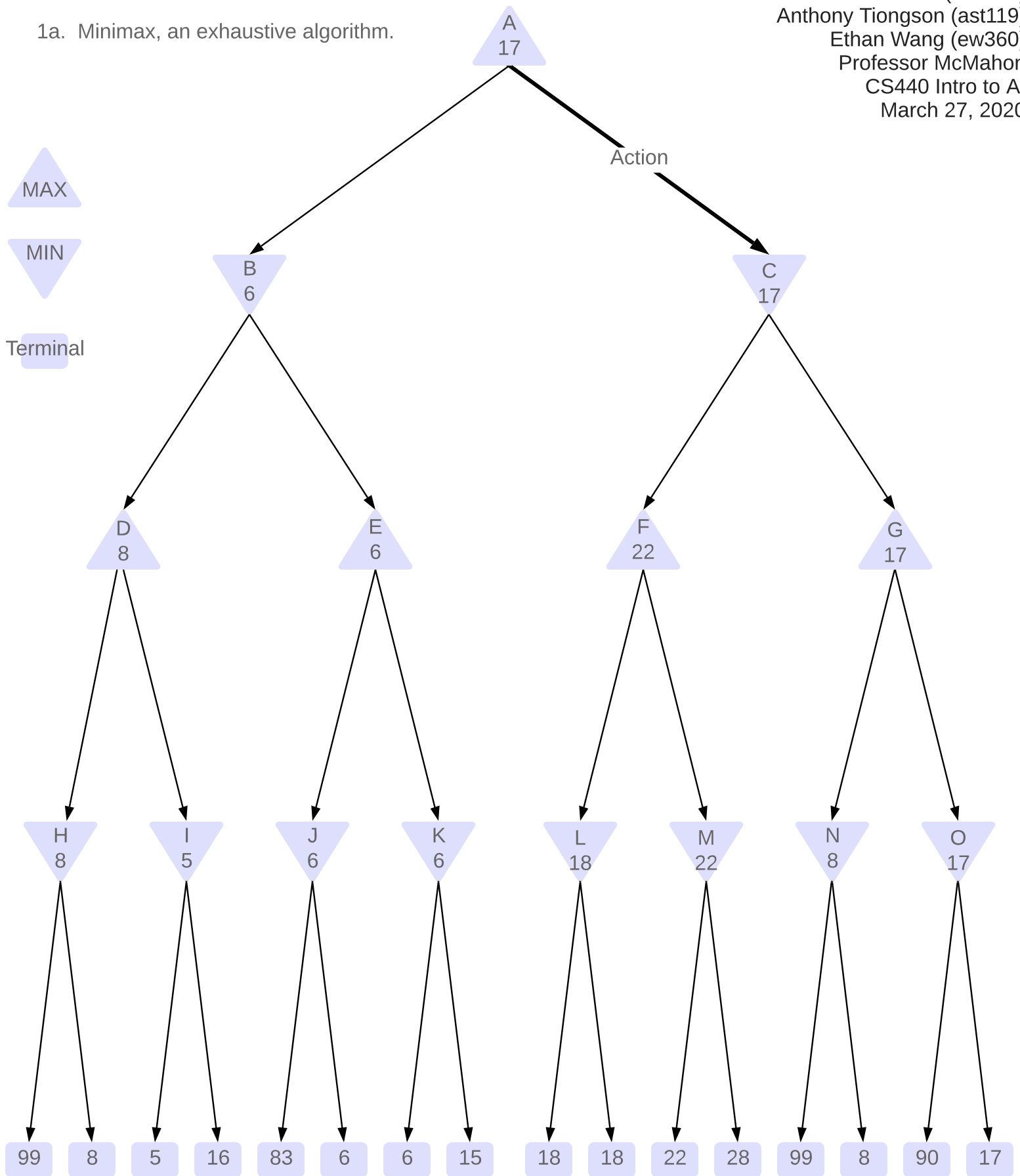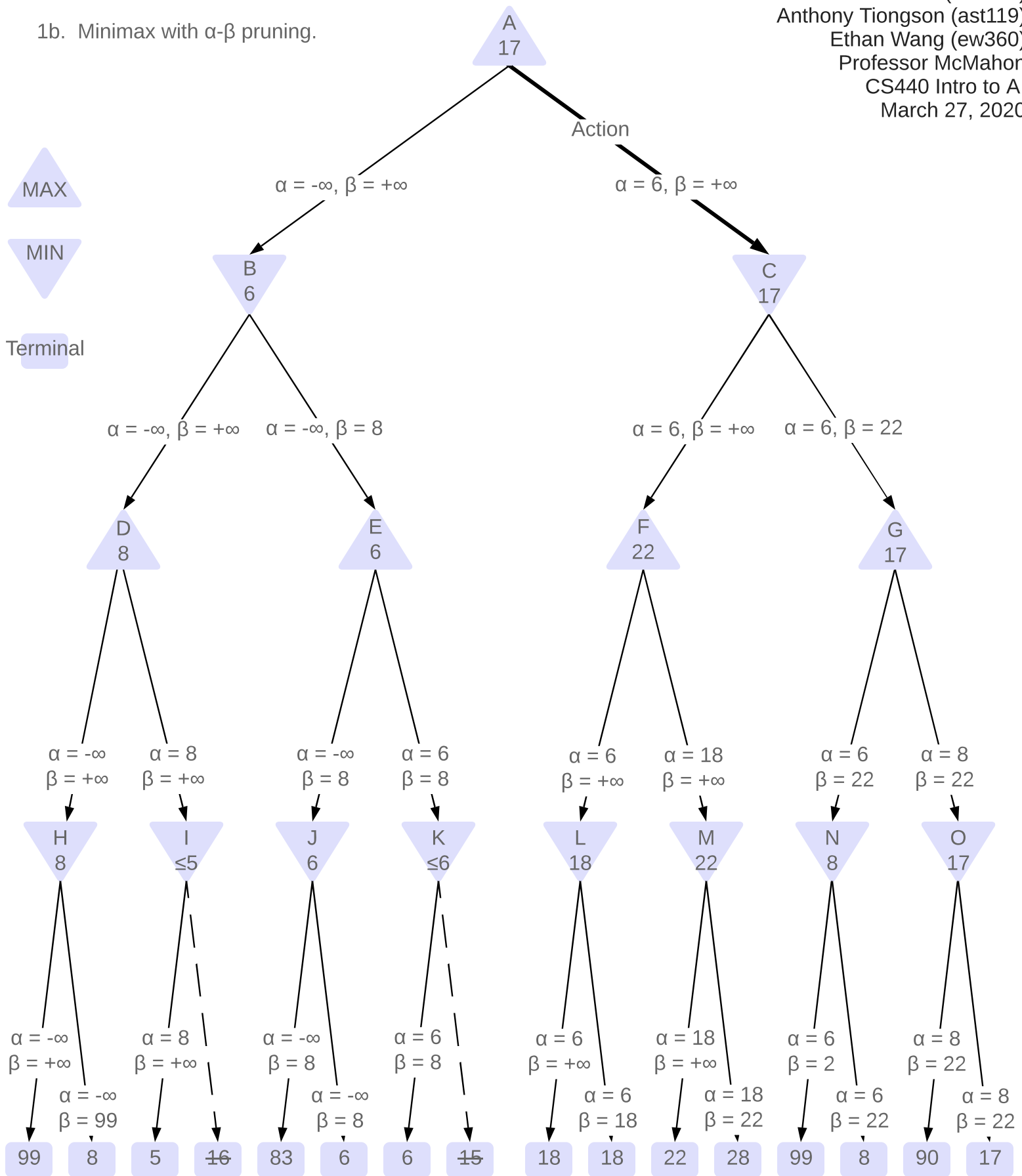
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1b. Minimax with α-β pruning.

MAX

MIN

Terminal

A
17

Action

$\alpha = -\infty, \beta = +\infty$

$\alpha = 6, \beta = +\infty$

B
6

C
17

$\alpha = -\infty, \beta = +\infty$

$\alpha = -\infty, \beta = 8$

$\alpha = 6, \beta = +\infty$

$\alpha = 6, \beta = 22$

D
8

E
6

F
22

G
17

$\alpha = -\infty$
$\beta = +\infty$

$\alpha = 8$
$\beta = +\infty$

$\alpha = -\infty$
$\beta = 8$

$\alpha = 6$
$\beta = 8$

$\alpha = 6$
$\beta = +\infty$

$\alpha = 18$
$\beta = +\infty$

$\alpha = 6$
$\beta = 22$

$\alpha = 8$
$\beta = 22$

H
8

I
≤5

J
6

K
≤6

L
18

M
22

N
8

O
17

$\alpha = -\infty$
$\beta = +\infty$

$\alpha = -\infty$
$\beta = 99$

$\alpha = 8$
$\beta = +\infty$

$\alpha = -\infty$
$\beta = 8$

$\alpha = -\infty$
$\beta = 8$

$\alpha = 6$
$\beta = 8$

$\alpha = 6$
$\beta = +\infty$

$\alpha = 6$
$\beta = 18$

$\alpha = 18$
$\beta = +\infty$

$\alpha = 18$
$\beta = 22$

$\alpha = 6$
$\beta = 2$

$\alpha = 6$
$\beta = 22$

$\alpha = 8$
$\beta = 22$

$\alpha = 8$
$\beta = 22$

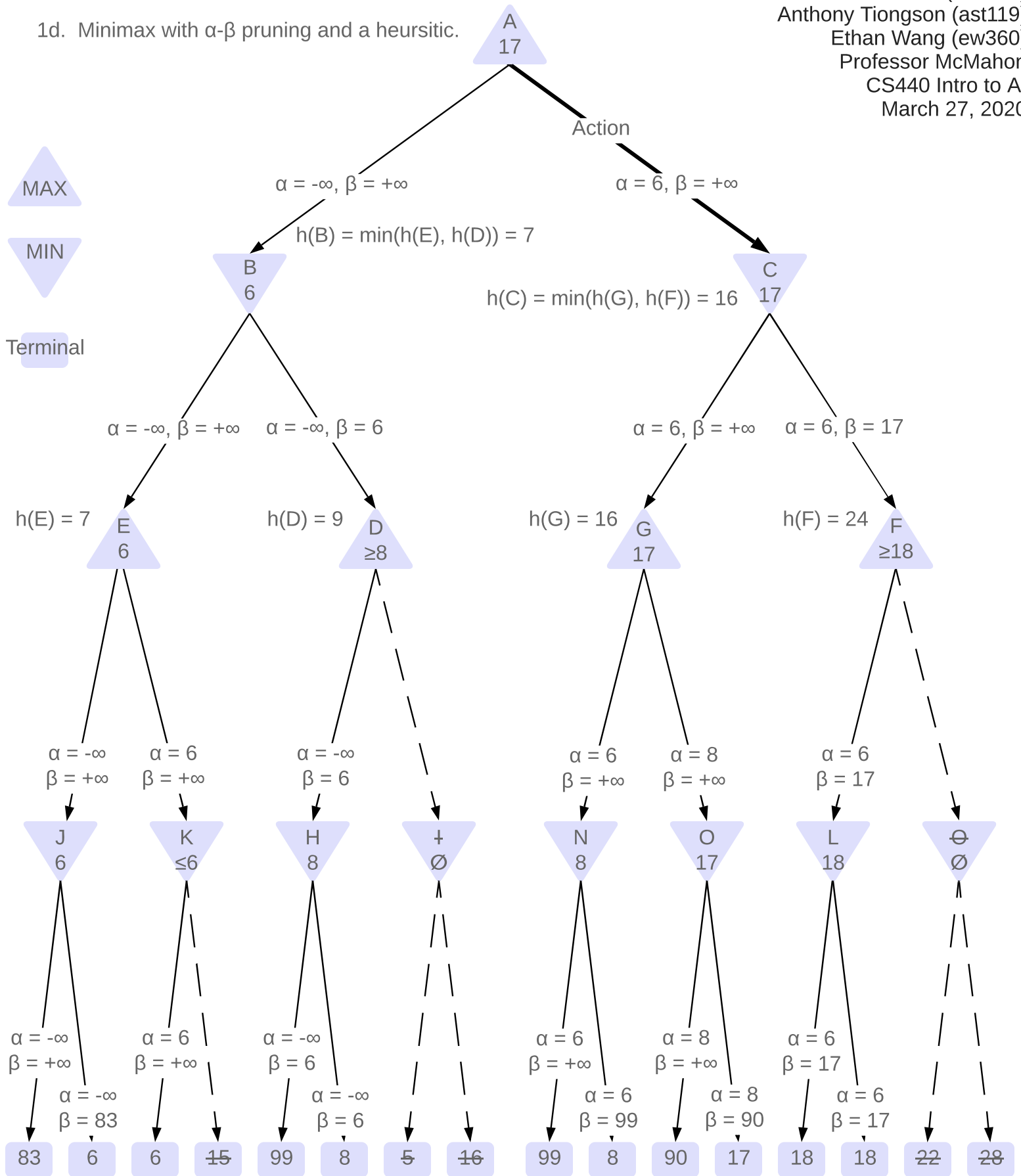99   8   5   ~~16~~   83   6   6   ~~15~~   18   18   22   28   99   8   90   17

2 nodes pruned.

1c.   The MAX player at the root state will make the **right** action in the exaustive minimax algorithm.
The MAX player will take the same **right** action when evaluating with α-β pruning. In general, the best
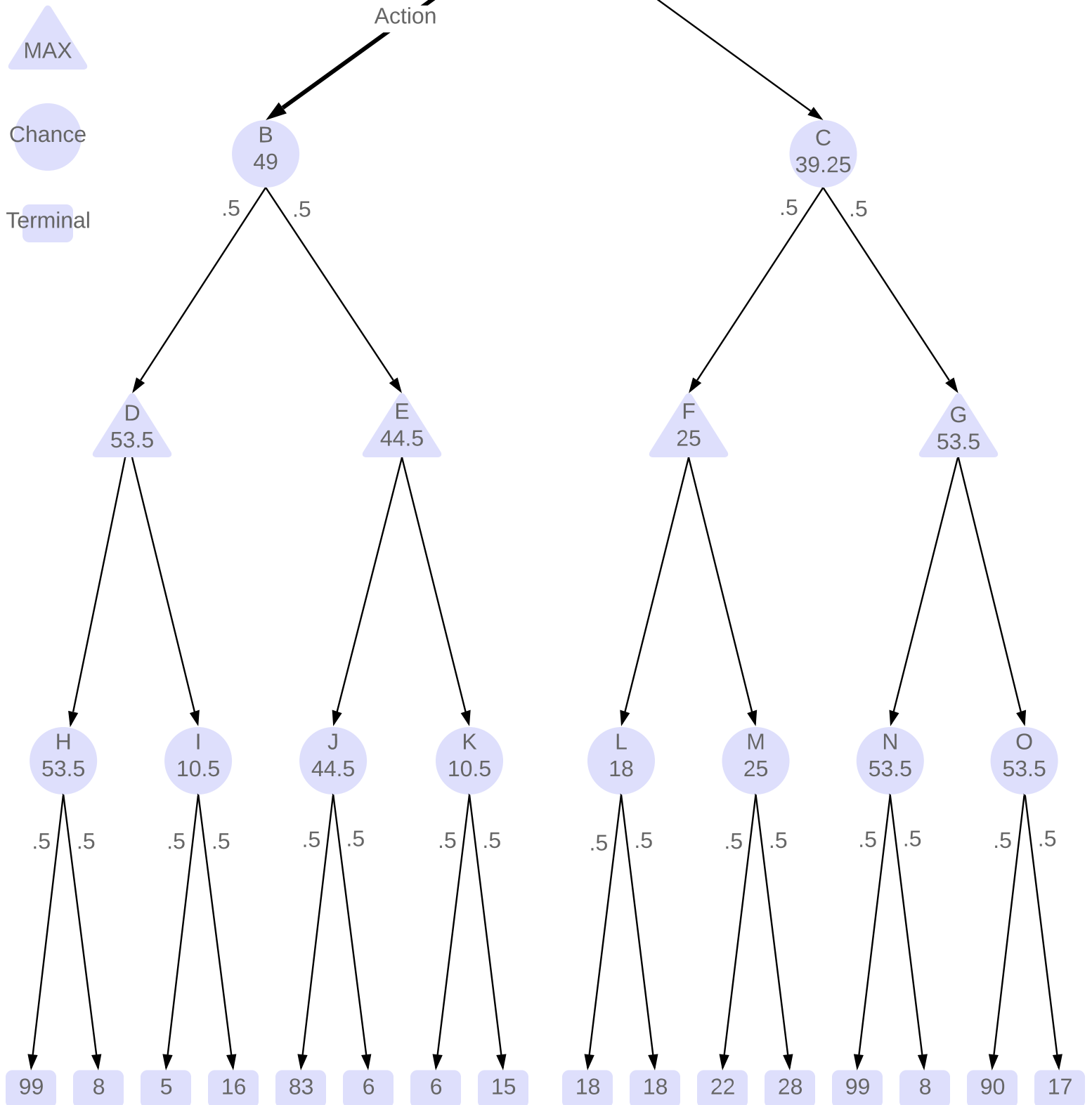move computed by both methods is guaranteed to be the same, which is why α-β pruning is so useful.

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1d. Minimax with α-β pruning and a heursitic.

MAX

MIN

Terminal

A
17

Action

α = -∞, β = +∞

α = 6, β = +∞

h(B) = min(h(E), h(D)) = 7

B
6

C
17

h(C) = min(h(G), h(F)) = 16

α = -∞, β = +∞

α = -∞, β = 6

α = 6, β = +∞

α = 6, β = 17

h(E) = 7

E
6

h(D) = 9

D
≥8

h(G) = 16

G
17

h(F) = 24

F
≥18

α = -∞
β = +∞

α = 6
β = +∞

α = -∞
β = 6

α = 6
β = +∞

α = 8
β = +∞

α = 6
β = 17

J
6

K
≤6

H
8

I
Ø

N
8

O
17

L
18

Q
Ø

α = -∞
β = +∞

α = -∞
β = 83

α = 6
β = +∞

α = -∞
β = 6

α = -∞
β = 6

α = 6
β = +∞

α = 6
β = 99

α = 8
β = +∞

α = 8
β = 90

α = 6
β = 17

α = 6
β = 17

83   6   6   15   99   8   5   16   99   8   90   17   18   18   22   28

7 nodes pruned.

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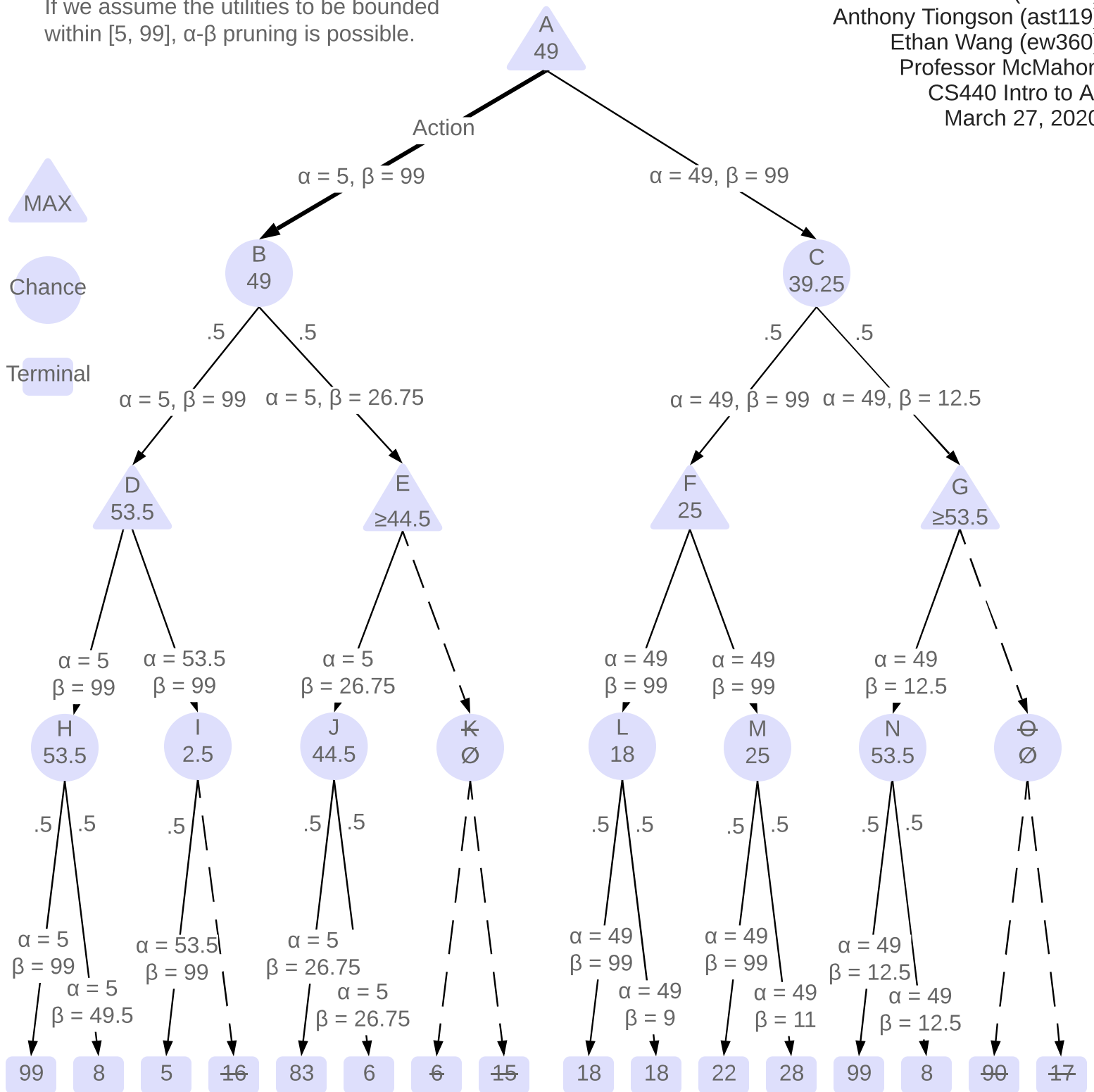Professor McMahon
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1e. Expectimax: the minimizing opponent's moves are governed by a given probability. It behaves and is evaluated more like an environment rather than an adversary. Expected value of the minimizer's moves is .50(left node) + .50(right node).

Without bounds for the utilities, pruning is not possible for expectimax and must be an exhaustive search. In this scenario, any unseen leaf node may possibly be the best or worst value for the tree. Expectimax is an algorithm that is not entirely safe since it has the chance of losing, and ignoring any nodes may greatly decrease its safetyness and effectiveness.

1e. Expectimax with α-β pruning.
   If we assume the utilities to be bounded
   within [5, 99], α-β pruning is possible.

Assignment 2

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MAX

Chance

Terminal

A
49

Action

α = 5, β = 99

α = 49, β = 99

B
49

C
39.25

.5   .5

.5   .5

α = 5, β = 99   α = 5, β = 26.75

α = 49, β = 99   α = 49, β = 12.5

D
53.5

E
≥44.5

F
25

G
≥53.5

α = 5
β = 99

α = 53.5
β = 99

α = 5
β = 26.75

α = 49
β = 99

α = 49
β = 99

α = 49
β = 12.5

H
53.5

I
2.5

J
44.5

K̶
∅

L
18

M
25

N
53.5

O̶
∅

.5 .5

.5

.5 .5

.5 .5

.5 .5

.5 .5

α = 5
β = 99

α = 5
β = 49.5

α = 53.5
β = 99

α = 5
β = 26.75

α = 5
β = 26.75

α = 49
β = 99

α = 49
β = 9

α = 49
β = 99

α = 49
β = 11

α = 49
β = 12.5

α = 49
β = 12.5

99   8   5   1̶6̶   83   6   6̶   1̶5̶   18   18   22   28   99   8   9̶0̶   1̶7̶

Talk about how to prune here.