## 2.4 $h = 2 * h'$

Since $h'$ multiplied the number of people by a large number, it does not matter if this large number is $X$ or $2 * X$. Therefore, all of the results will remain the same, and the heuristic is still admissible.

# Exercise 3 Game trees

## 3.1 Each agent out for itself, and they cannot communicate.

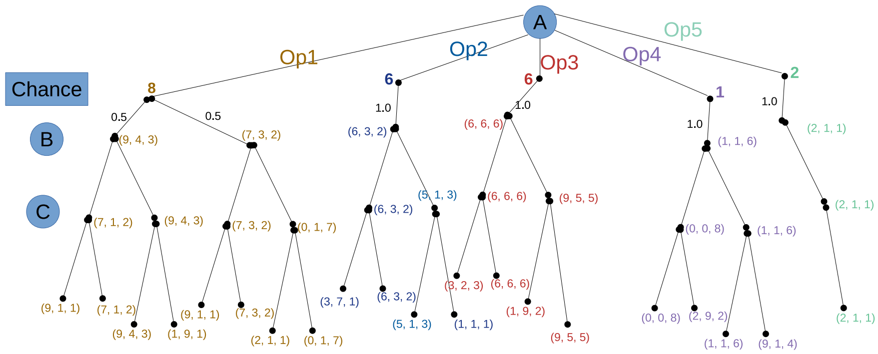


Figure 5: Option 1 is the best

## 3.2 Paranoid assumption: B and C are against A

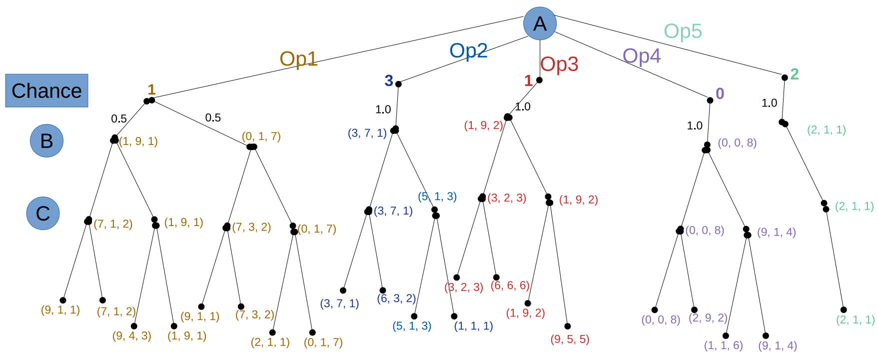


Figure 6: Option 2 is the best

## 3.3 B and C may agree on a deal if it is beneficial to both of them

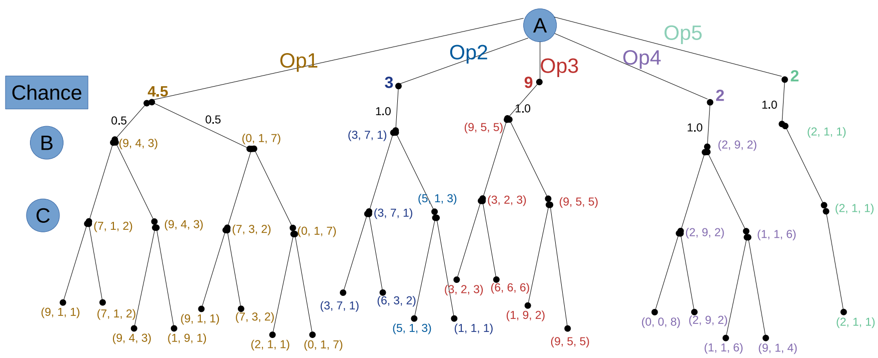


Figure 7: Option 3 is the best

### 3.4 A and C are partners aiming to maximize the sum of their scores

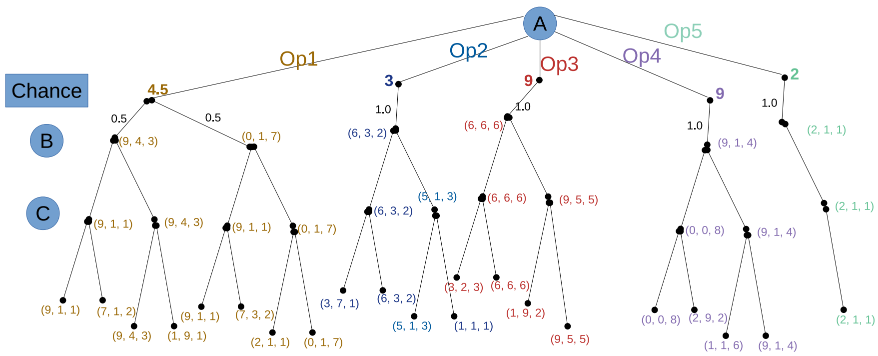


Figure 8: Option 4 is the best

### 3.5 A is a firm believer in Murphy's laws: "mother nature is a b*!=h", and wants toplay absolutely safe.

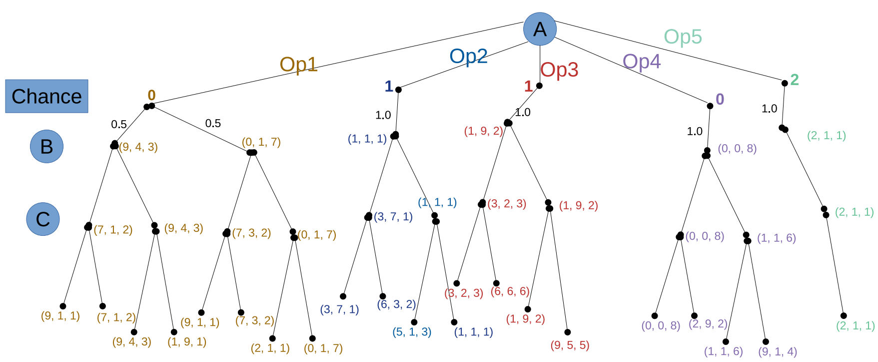


Figure 9: Option 5 is the best

## Exercise 4 Game-tree search - alpha-beta pruning

### 4.1 Construct an example where the optimal first move is no-op

Assuming the world shown in Fig. 10. K=0 and Deadline=5. In this world B is a vandal agent that works as follows: He moves one turn, destroying the traversed edge, and then does NoOp() one turn. The agent A is at V4 and already carrying people (number does not matter). The agent wants to get to the shelter, however, he must see first what B will do. If B goes to V1, A have to be at V1 already, because next move B might go to the shelter and A won't be able to save the carrying people. However, if B goes to V2 or V3 first, the optimal solution will be to save an additional person.

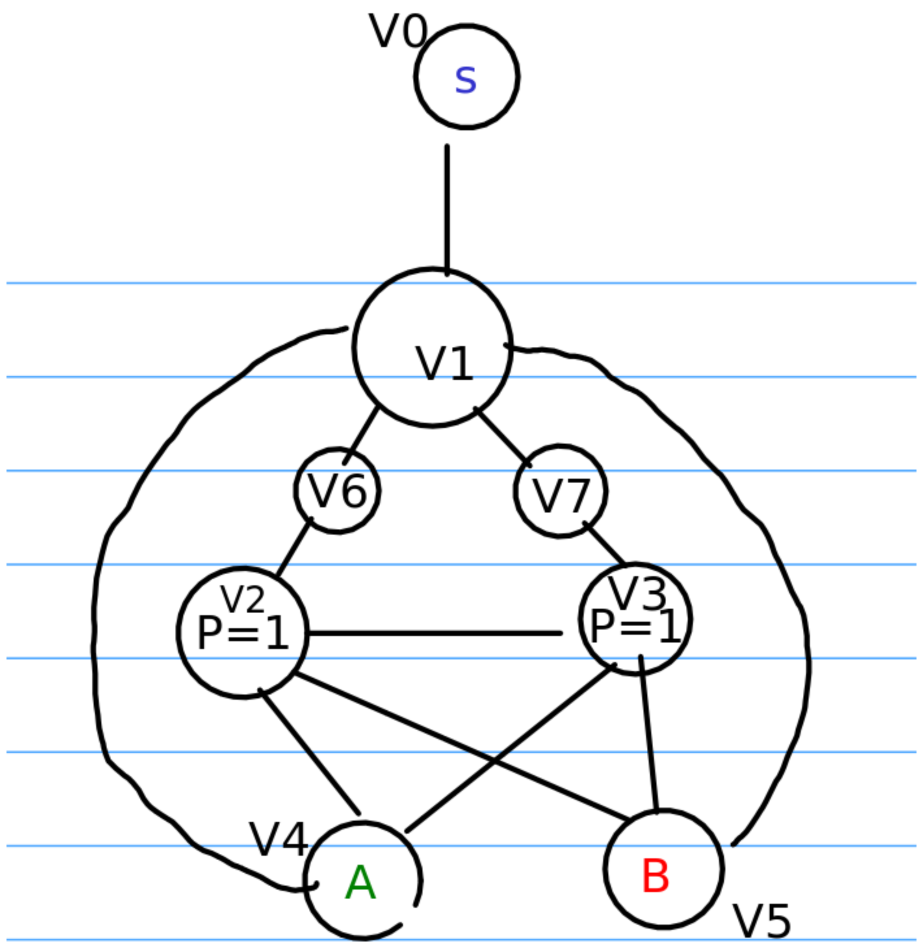


Figure 10: World where all edges are 1. B is a vandal agent that waits 1 turn in place, and one turn moves randomly and destroys the traversed edge. A is carrying 1 person and should wait to see what B does first.

### 4.2 Construct and show an example

Using the heuristic of calculating how many people will not be saved, the expansion tree is given for the choices of agent A. At first it can go to V2, V3 or do NoOp. For each option, the B agent will randomly go to either V2, V3 or V1 with probability of 1/3.

As seen by Fig. 11, If agent A will go to V2 or V3 there is a possibility that the agent will finish the game with a very high heuristic value, therefore, the h value is 466.

However, if agent A will do No-Op then it has enough time to react to agent's B decision.

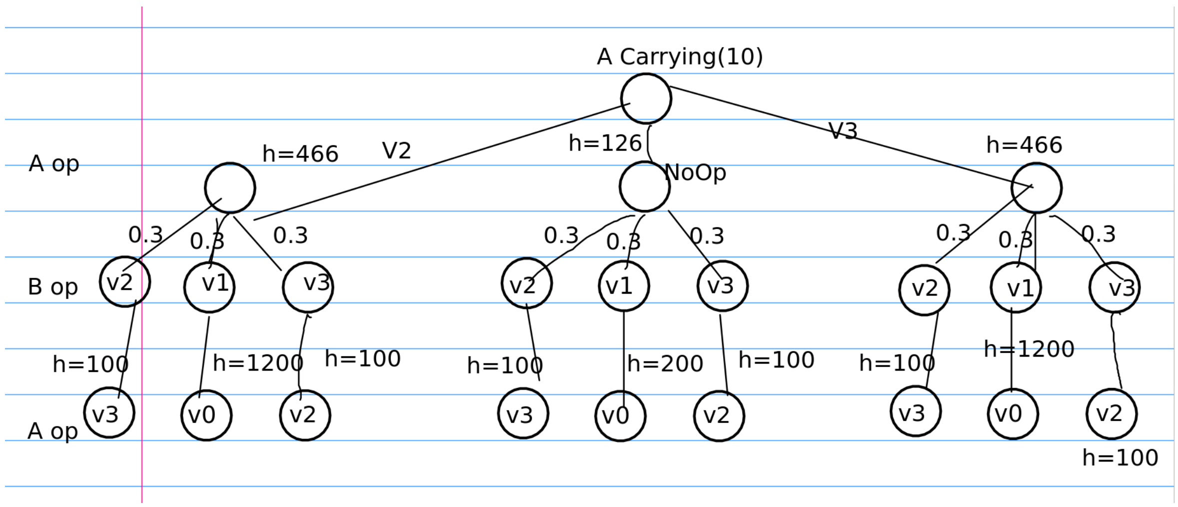


Figure 11: Expansion tree.

### 4.3 Show where alpha-beta pruning can decrease search effort in the tree from b

Assume that we start expanding V2. After the choice of agent B, several of the remaining choices can be discarded. In addition (and mostly), due to symmetry, expanding V3 will be futile and will finish this branch much faster.

## Exercise 5 Propositional logic

For validity it will be shown that the sentence is always true.

An example for satisfiability a true model and a false model will be given.

For unsatisfiability it will be shown that the setence is always false.

Number of models equals to: $2^n$, if the sentence is valid, where n is the number of symbols.

### 5.1 $(\neg A \wedge \neg B \wedge \neg C \wedge \neg D \wedge \neg E \wedge F) \vee (A \wedge B \wedge C \wedge D \wedge E)$

*True model* - A, B, C, D, F are true, therefore,

$True \vee False = True$

*False model* - A is true, B is false (the rest whatever), therefore,

$False \vee False = False$

**Satisfiable**. Number of satisfiable models is 3.

## 5.2 $(\neg A \lor \neg B \lor \neg C \lor \neg D \lor \neg E \lor \neg F) \land (A \lor B \lor C \lor D \lor E \lor F)$

*False model* - A, B, C, D, F are true, therefore,

$True \land False = False$

*True model* - A is true, B is false (the rest whatever), therefore,

$True \land True = True$

**Satisfiable**. Number of satisfiable models is 62.

## 5.3 $(A \lor B \land (D \lor \neg A) \land (E \lor A) \Rightarrow (B \lor C \land (\neg D \lor E))) \land (A \land \neg A)$

$\alpha \equiv (A \lor B \land (D \lor \neg A) \land (E \lor A) \Rightarrow (B \lor C \land (\neg D \lor E)))$

$\alpha \land (A \land \neg A) \rightarrow \alpha \land False \rightarrow False$

**Unsatisfiable** Number of models is 0.

## 5.4 $(A \land (A \Rightarrow B) \land (B \Rightarrow C)) \Rightarrow C$

**implication elimination** $\neg(A \land (\neg A \lor B) \land (\neg B \lor C)) \lor C$

**Distributivity** $\neg((A \land \neg A) \lor (A \land B)) \land (\neg B \lor C)) \lor C$

$\neg(False \lor (A \land B)) \land (\neg B \lor C)) \lor C$

**Associativity** $\neg(A \land (B \land (\neg B \lor C))) \lor C$

**Distributivity** $\neg(A \land ((B \land \neg B) \lor (B \land C))) \lor C$

$\neg(A \land ((False) \lor (B \land C))) \lor C$

$\neg(A \land (B \land C)) \lor C$

**De Morgan** $\neg A \lor \neg B \lor \neg C \lor C \rightarrow True$

**Valid**. Number of models is 8.

## 5.5 $\neg((A \land (A \Rightarrow B) \land (B \Rightarrow C)) \Rightarrow C)$

**implication elimination** $\neg(\neg(A \land (\neg A \lor B) \land (\neg B \land C)) \lor C)$

**Distributivity** $\neg(\neg((A \land \neg A) \lor (A \land B) \land (\neg B \land C)) \lor C)$

$\neg(\neg((A \land B) \land (\neg B \land C)) \lor C)$

**De Morgan** $\neg(\neg A \lor \neg B \lor \neg\neg B \lor \neg C \lor C)$

**Double negation elimination** $\neg(\neg A \lor \neg B \lor B \lor \neg C \lor C) \rightarrow$

$\neg(\neg A \lor True \lor True) \rightarrow$

$\neg(True) \rightarrow False$

**Unsatisfiable**. Number of models is 0.