**Assignment 7**

**Task 2:**

**Constants:**

ADULT\_1, ADULT\_2, ADULT\_3, CHILDREN\_1, CHILDREN\_2, CHILDREN\_3, BOAT\_B

**Predicates:**

CHILDREN(X): It is TRUE if X is a child.

ADULT(X): It is TRUE if X is a adult.

BOAT(X): It is TRUE if X is a boat.

LEFT(X): It is TRUE if X is on left side of river.

RIGHT(X): It is TRUE if X is on right side of river.

**Initial State:**

ADULT(ADULT\_1) AND ADULT(ADULT\_2)

AND ADULT(ADULT\_3) AND CHILDREN(CHILDREN\_1) AND CHILDREN(CHILDREN\_2) AND CHILDREN(CHILDREN\_3) AND BOAT(BOAT\_B) AND LEFT(ADULT\_1) AND LEFT(ADULT\_2)

AND LEFT(ADULT\_3) AND LEFT(CHILDREN\_1) AND LEFT(CHILDREN\_2) AND LEFT(CHILDREN\_3) AND LEFT(BOAT\_B)

**Goal State:**

RIGHT(ADULT\_1) AND RIGHT(ADULT\_2)

AND RIGHT(ADULT\_3) AND RIGHT(CHILDREN\_1) AND RIGHT(CHILDREN\_2) AND RIGHT(CHILDREN\_3) AND RIGHT(BOAT\_B)

**Operations:**

1. ACTION(MOVERIGHT\_ONE(x, y))

PRECOND: (LEFT x) AND (LEFT y) AND (BOAT y)

EFFECT: (RIGHT x) AND (RIGHT y) AND NOT(LEFT x) AND NOT(LEFT y)

1. ACTION(MOVERIGHT\_TWO(x, y, z))

PRECOND: (LEFT x) AND (LEFT y) AND (LEFT z) AND (CHILDREN x) AND (CHILDREN y) AND (BOAT z)

EFFECT: (RIGHT x) AND (RIGHT y) AND (RIGHT z) AND NOT(LEFT x) AND NOT(LEFT y) AND NOT(LEFT z)

1. ACTION(MOVELEFT\_ONE(x, y))

PRECOND: (RIGHT x) AND (RIGHT y) AND (BOAT y)

EFFECT: (LEFT x) AND (LEFT y) AND NOT(RIGHT x) AND NOT(RIGHT y)

1. ACTION(MOVELEFT\_TWO(x, y, z))

PRECOND: (RIGHT x) AND (RIGHT y) AND (RIGHT z) AND (CHILDREN x) AND (CHILDREN y) AND (BOAT z)

EFFECT: (LEFT x) AND (LEFT y) AND (LEFT z) AND NOT(RIGHT x) AND NOT(RIGHT y) AND NOT(RIGHT z)

**Plan Actions:**

1. ACTION(MOVERIGHT\_CHILDREN(CHILDREN\_1, CHILDREN\_2, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_1) AND CHILDREN(CHILDREN\_2) AND BOAT(BOAT\_B) AND LEFT(CHILDREN\_1) AND LEFT(CHILDREN\_2) AND LEFT(BOAT\_B)

EFFECT: RIGHT(CHILDREN\_1) AND RIGHT(CHILDREN\_2) AND RIGHT(BOAT\_B) AND NOT(LEFT(CHILDREN\_1)) AND NOT(LEFT(CHILDREN\_2)) AND NOT(LEFT(BOAT\_B))

1. ACTION(MOVELEFT\_CHILDREN(CHILDREN\_1, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_1) AND BOAT(BOAT\_B) AND RIGHT(CHILDREN\_1) AND RIGHT(BOAT\_B)

EFFECT: LEFT(CHILDREN\_1) AND LEFT(BOAT\_B) AND NOT(RIGHT(CHILDREN\_1)) AND NOT(RIGHT(BOAT\_B))

1. ACTION(MOVERIGHT\_CHILDREN(CHILDREN\_1, CHILDREN\_3, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_1) AND CHILDREN(CHILDREN\_3) AND BOAT(BOAT\_B) AND LEFT(CHILDREN\_1) AND LEFT(CHILDREN\_3) AND LEFT(BOAT\_B)

EFFECT: RIGHT(CHILDREN\_1) AND RIGHT(CHILDREN\_3) AND RIGHT(BOAT\_B) AND NOT(LEFT(CHILDREN\_1)) AND NOT(LEFT(CHILDREN\_3)) AND NOT(LEFT(BOAT\_B))

1. ACTION(MOVELEFT\_CHILDREN(CHILDREN\_1, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_1) AND BOAT(BOAT\_B) AND RIGHT(CHILDREN\_1) AND RIGHT(BOAT\_B)

EFFECT: LEFT(CHILDREN\_1) AND LEFT(BOAT\_B) AND NOT(RIGHT(CHILDREN\_1)) AND NOT(RIGHT(BOAT\_B))

1. ACTION(MOVERIGHT\_ADULT(ADULT\_1, CHILDREN\_2, BOAT\_B))

PRECOND: ADULT(ADULT\_1) AND CHILDREN(CHILDREN\_2) AND BOAT(BOAT\_B) AND LEFT(ADULT\_1) AND RIGHT(CHILDREN\_2) AND LEFT(BOAT\_B)

EFFECT: RIGHT(ADULT\_1) AND RIGHT(BOAT\_B) AND NOT(LEFT(ADULT\_1)) AND NOT(LEFT(BOAT\_B))

1. ACTION(MOVELEFT\_CHILDREN(CHILDREN\_2, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_2) AND BOAT(BOAT) AND RIGHT(CHILDREN\_2) AND RIGHT(BOAT\_B)

EFFECT: LEFT(CHILDREN\_2) AND LEFT(BOAT\_B) AND NOT(RIGHT(CHILDREN\_2)) AND NOT(RIGHT(BOAT\_B))

1. ACTION(MOVERIGHT\_ADULT(ADULT\_2, CHILDREN\_3, BOAT\_B))

PRECOND: ADULT(ADULT\_2) AND CHILDREN(CHILDREN\_3) AND BOAT(BOAT\_B) AND LEFT(ADULT\_2) AND RIGHT(CHILDREN\_3) AND LEFT(BOAT\_B)

EFFECT: RIGHT(ADULT\_2) AND RIGHT(BOAT\_B) AND NOT(LEFT(ADULT\_2)) AND NOT(LEFT(BOAT\_B))

1. ACTION(MOVELEFT\_CHILDREN(CHILDREN\_3, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_3) AND BOAT(BOAT) AND RIGHT(CHILDREN\_3) AND RIGHT(BOAT\_B)

EFFECT: LEFT(CHILDREN\_3) AND LEFT(BOAT\_B) AND NOT(RIGHT(CHILDREN\_3)) AND NOT(RIGHT(BOAT\_B))

1. ACTION(MOVERIGHT\_CHILDREN(CHILDREN\_1, CHILDREN\_3, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_1) AND CHILDREN(CHILDREN\_3) AND BOAT(BOAT\_B) AND LEFT(CHILDREN\_1) AND LEFT(CHILDREN\_3) AND LEFT(BOAT\_B)

EFFECT: RIGHT(CHILDREN\_1) AND RIGHT(CHILDREN\_3) AND RIGHT(BOAT\_B) AND NOT(LEFT(CHILDREN\_1)) AND NOT(LEFT(CHILDREN\_3)) AND NOT(LEFT(BOAT\_B))

1. ACTION(MOVELEFT\_CHILDREN(CHILDREN\_3, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_3) AND BOAT(BOAT\_B) AND RIGHT(CHILDREN\_3) AND RIGHT(BOAT)

EFFECT: LEFT(CHILDREN\_3) AND LEFT(BOAT\_B) AND NOT(RIGHT(CHILDREN\_3)) AND NOT(RIGHT(BOAT\_B))

1. ACTION(MOVERIGHT\_ADULT(ADULT\_3, CHILDREN\_1, BOAT\_B))

PRECOND: ADULT(ADULT\_3) AND CHILDREN(CHILDREN\_1) AND BOAT(BOAT\_B) AND LEFT(ADULT\_3) AND RIGHT(CHILDREN\_1) AND LEFT(BOAT\_B)

EFFECT: RIGHT(ADULT\_3) AND RIGHT(BOAT\_B) AND NOT(LEFT(ADULT\_3)) AND NOT(LEFT(BOAT\_B))

1. ACTION(MOVELEFT\_CHILDREN(CHILDREN\_1, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_1) AND BOAT(BOAT\_B) AND RIGHT(CHILDREN\_1) AND RIGHT(BOAT\_B)

EFFECT: LEFT(CHILDREN\_1) AND LEFT(BOAT\_B) AND NOT(RIGHT(CHILDREN\_1)) AND NOT(RIGHT(BOAT\_B))

1. ACTION(MOVERIGHT\_CHILDREN(CHILDREN\_1, CHILDREN\_2, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_1) AND CHILDREN(CHILDREN\_2) AND BOAT(BOAT\_B) AND LEFT(CHILDREN\_1) AND LEFT(CHILDREN\_2) AND LEFT(BOAT\_B)

EFFECT: RIGHT(CHILDREN\_1) AND RIGHT(CHILDREN\_2) AND RIGHT(BOAT\_B) AND NOT(LEFT(CHILDREN\_1)) AND NOT(LEFT(CHILDREN\_2)) AND NOT(LEFT(BOAT\_B))

1. ACTION(MOVELEFT\_CHILDREN(CHILDREN\_2, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_2) AND BOAT(BOAT\_B) AND RIGHT(CHILDREN\_2) AND RIGHT(BOAT\_B)

EFFECT: LEFT(CHILDREN\_2) AND LEFT(BOAT\_B) AND NOT(RIGHT(CHILDREN\_2)) AND NOT(RIGHT(BOAT\_B))

1. ACTION(MOVERIGHT\_CHILDREN(CHILDREN\_2, CHILDREN\_3, BOAT\_B))

PRECOND: CHILDREN(CHILDREN\_2) AND CHILDREN(CHILDREN\_3) AND BOAT(BOAT\_B) AND LEFT(CHILDREN\_2) AND LEFT(CHILDREN\_3) AND LEFT(BOAT\_B)

EFFECT: RIGHT(CHILDREN\_2) AND RIGHT(CHILDREN\_3) AND RIGHT(BOAT\_B) AND NOT(LEFT(CHILDREN\_2)) AND NOT(LEFT(CHILDREN\_3)) AND NOT(LEFT(BOAT\_B))

**Task 3:**

There are 5 predicates, each predicate takes at most 3 arguments and there are 4 constants.

Total number of combinations for 1 arguments = 4^1 = 4

Therefore, there can be 4 combinations for each predicate.

For 5 predicates, 5\*4 = 20 values.

Each predicate can return TRUE or FALSE; therefore, total number of unique states = 2^20 states.

Total number of combinations for 3 arguments = 4^3 = 64

Therefore, there can be 64 combinations for each predicate.

For 5 predicates, 5\*64 = 320 values.

Each predicate can return TRUE or FALSE; therefore, total number of unique states = 2^320 states.

Therefore, tight bound on the number of unique states in the JUNGLE world is in between 2^20 and 2^320.

**Task 4:**

ACTION(aaa(B ttt1, C ttt1))

PRECOND: (ppp1 B C) AND (ppp2 B) AND (ppp3 C)

EFFECT: (eee1 B C) AND (eee2 B) AND NOT(eee2 C) AND NOT(eee3 C)

Resulting State:

(A ttt1)

(B ttt1)

(C ttt1)

(ppp1 B C)

(ppp2 A)

(ppp2 B)

(ppp3 C)

(eee1 A C)

(eee1 B C)

(eee2 B)

(eee3 A)

**Task 5:**

Execution Monitoring/Online Replanning:

When online replanning is used, action definitions remains same. Before executing any action we check if the world is in expected state; if yes, then we execute the action as defined.

Conditional Planning:

ACTION: MOVERIGHT\_ONE(x, y)

PRECOND: (LEFT x) AND (LEFT y) AND (BOAT y)

EFFECT: ((RIGHT x) AND (RIGHT y) AND NOT(LEFT x) AND NOT(LEFT y)) OR ((LEFT x) AND (LEFT y))

ACTION: MOVELEFT\_ONE(x, y)

PRECOND: (RIGHT x) AND (RIGHT y) AND (BOAT y)

EFFECT: ((LEFT x) AND (LEFT y) AND NOT(RIGHT x) AND NOT(RIGHT y)) OR ((RIGHT x) AND (RIGHT y))