# RS-HL-13: Multi User Default Code

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## I. Load the Dataset

```
clear;clc;
% Load the Satellite Contat Dataset
addpath('~/Desktop/Redstone_Project/RS_HL/RS_HL_10_TV_MDP_Functions')
load('/workspace/RS_Dataset/RS_HL_3_dataset.mat')
```

## II. Destination Setting and Time Index Vector Setting

```
time_index_vector = 100:130;
start_time_index = 100:120;
%
% destination_1 = 10;
% destination_2 = 12;
% destination_3 = 18;
% destination_4 = 27;
% destination_5 = 40;


number_of_agents = 25;
number_of_destinations = 4;
state_vector = 1:48;


start_state = state_vector(randi(numel(state_vector), 1, number_of_agents));
destination_values = randsample(state_vector,number_of_destinations);
destination_state = destination_values(randi(numel(destination_values), 1,
number_of_agents));
start_time = start_time_index(randi(numel(start_time_index), 1,
number_of_agents));
```

### II.1 Run the MDP simulation for each destination

```

number_of_destination = length(destination_values);
```

```
for destination_index = 1:number_of_destination

    MDP.(['MDP', num2str(destination_values(destination_index))])
= runMDP(sat_to_sat_contact_3d_matrix,
time_index_vector,destination_values(destination_index));

end
```

```
simulation set up complete!
Policy: 1 -> Value Iteration: 434
Policy: 2 -> Value Iteration: 14
Policy: 3 -> Value Iteration: 10
Policy: 4 -> Value Iteration: 6
Policy: 5 -> Value Iteration: 5
Policy: 6 -> Value Iteration: 11
Policy: 7 -> Value Iteration: 4
Policy: 8 -> Value Iteration: 3
simulation set up complete!
Policy: 1 -> Value Iteration: 458
Policy: 2 -> Value Iteration: 14
Policy: 3 -> Value Iteration: 5
Policy: 4 -> Value Iteration: 5
Policy: 5 -> Value Iteration: 7
Policy: 6 -> Value Iteration: 6
Policy: 7 -> Value Iteration: 5
Policy: 8 -> Value Iteration: 1
simulation set up complete!
Policy: 1 -> Value Iteration: 438
Policy: 2 -> Value Iteration: 14
Policy: 3 -> Value Iteration: 6
Policy: 4 -> Value Iteration: 5
Policy: 5 -> Value Iteration: 6
Policy: 6 -> Value Iteration: 4
Policy: 7 -> Value Iteration: 11
Policy: 8 -> Value Iteration: 1
simulation set up complete!
Policy: 1 -> Value Iteration: 433
Policy: 2 -> Value Iteration: 14
Policy: 3 -> Value Iteration: 11
Policy: 4 -> Value Iteration: 8
Policy: 5 -> Value Iteration: 11
Policy: 6 -> Value Iteration: 7
Policy: 7 -> Value Iteration: 5
Policy: 8 -> Value Iteration: 5
Policy: 9 -> Value Iteration: 3
```

## III. Configure each Agent's Setting

```
agents_input = [start_time', start_state', destination_state'];
```

## IV. Configure the simulation structure setting

```
% Level 1: Initialize simulation structure
sim = struct();

for time_index = time_index_vector
    sim.(['time' num2str(time_index)]) = {};
end

% Level 2/3: Initialize Agent (Level 2) with States and Destination (Level 3)

number_of_agents = length(agents_input(:,1));

for agent_index = 1:number_of_agents
   sim.(['time' num2str(agents_input(agent_index,1))]).(['agent'
num2str(agent_index)]).('state') = agents_input(agent_index,2);
   sim.(['time' num2str(agents_input(agent_index,1))]).(['agent'
num2str(agent_index)]).('destination') = agents_input(agent_index,3);
end
```

### V. Propagation of agents' state

```
collision_flag = false;

for time_index = time_index_vector

    % If there's no active agent, continue to next time step
    if isempty(sim.(['time' num2str(time_index)]))
       continue;
    end


    % Parse the number of active agents
    number_of_active_agents = length(fieldnames(sim.(['time'
num2str(time_index)])));

    % Make the status matrix represents current and next
    % [current_state, next_state, destination]
    status_matrix = zeros(3, number_of_active_agents);

    agents_list = fieldnames(sim.(['time' num2str(time_index)]));

    % Find the Next state from Current Agent-State
    for active_agent_index = 1:number_of_active_agents
        % Find the Current State and Destination of given agent
        current_state = sim.(['time' num2str(time_index)]).
(agents_list{active_agent_index}).('state');
        destination = sim.(['time' num2str(time_index)]).
(agents_list{active_agent_index}).('destination');
```

```
        % Find the Next state from given MDP pi distribution
        pi_dist = MDP.(['MDP' num2str(destination)]).(['time'
num2str(time_index)]).('policy_distribution');
        action_number = find(pi_dist(current_state,:) ~= 0);

        if length(action_number) > 1
        action_number = randsample(action_number,1);
        end

        next_state = MDP.(['MDP' num2str(destination)]).(['time'
num2str(time_index)]).(['state' num2str(current_state)]).(['action'
num2str(action_number)]).('success').('next_state');
        reward = MDP.(['MDP' num2str(destination)]).(['time'
num2str(time_index)]).(['state' num2str(current_state)]).(['action'
num2str(action_number)]).('success').('reward');
        state_value =  MDP.(['MDP' num2str(destination)]).(['time'
num2str(time_index)]).(['state' num2str(current_state)]).('state_value');
        action_value  = MDP.(['MDP' num2str(destination)]).
(['time' num2str(time_index)]).(['state' num2str(current_state)]).(['action'
num2str(action_number)]).('action_value');

        % Configure Proposed status matrix for the collision test
        status_matrix(1,active_agent_index) = current_state;
        status_matrix(2,active_agent_index) = next_state;
        status_matrix(3,active_agent_index) = destination;

        % Add State Value
        sim.(['time' num2str(time_index)]).(agents_list{active_agent_index}).
('state_value') = state_value;

        % Save the Original Reward and action value to prepare the update
        sim.(['time' num2str(time_index)]).(agents_list{active_agent_index}).
('original_action_number') = action_number;
        sim.(['time' num2str(time_index)]).(agents_list{active_agent_index}).
('original_action_value') = action_value;
        sim.(['time' num2str(time_index)]).(agents_list{active_agent_index}).
('original_reward') = reward;

        % Add the action number, reward, action value (may be changed)
        sim.(['time' num2str(time_index)]).(agents_list{active_agent_index}).
('action_number') = action_number;
        sim.(['time' num2str(time_index)]).(agents_list{active_agent_index}).
('action_value') = action_value;
        sim.(['time' num2str(time_index)]).(agents_list{active_agent_index}).
('reward') = reward;
    end


    % Break when time index reaches the end time
```

```
    if time_index == max(time_index_vector)
       break;
    end

    for active_agent_index = 1:number_of_active_agents

        % Don't update the agent already arrived to destination
        if status_matrix(1,active_agent_index) ==
status_matrix(3,active_agent_index)
            continue;
        end

        % Update the time+1 for next state
        sim.(['time' num2str(time_index+1)]).
(agents_list{active_agent_index}).('state') =
status_matrix(2,active_agent_index);
        sim.(['time' num2str(time_index+1)]).
(agents_list{active_agent_index}).('destination') =
status_matrix(3,active_agent_index);
    end
end
```

## VI. result display

```
result_matrix = zeros(length(time_index_vector),number_of_agents);
reward_matrix =  zeros(length(time_index_vector),number_of_agents);
state_value_matrix = zeros(length(time_index_vector),number_of_agents);
action_value_matrix = zeros(length(time_index_vector),number_of_agents);
cumulative_reward_matrix = zeros(length(time_index_vector),number_of_agents);

for time_index = time_index_vector

    if isempty(sim.(['time' num2str(time_index)]))
     continue;
    end

    agents_list = fieldnames(sim.(['time' num2str(time_index)]));
    number_of_agents = length(agents_list);

    for agent_index = 1:number_of_agents
        agent_name = cell2mat(agents_list(agent_index));
        agent_no = regexp(agent_name, '\d+','match');
        agent_number = str2double(agent_no{1});

        result_matrix(time_index - min(time_index_vector) + 1,agent_number)
= sim.(['time' num2str(time_index)]).(agent_name).('state');
        reward_matrix(time_index - min(time_index_vector) + 1,agent_number)
=  sim.(['time' num2str(time_index)]).(agent_name).('reward');
```

```
        state_value_matrix(time_index - min(time_index_vector)
+ 1,agent_number) = sim.(['time' num2str(time_index)]).(agent_name).
('state_value');
        action_value_matrix(time_index - min(time_index_vector)
+ 1,agent_number) = sim.(['time' num2str(time_index)]).(agent_name).
('action_value');
        cumulative_reward_matrix(time_index - min(time_index_vector) +
1,agent_number) = sum(reward_matrix(1:time_index - min(time_index_vector) +
1,agent_number));

    end

end

result = [time_index_vector' , result_matrix]
```

result = 31×26

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ⋯ |
| 101 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 102 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | |
| 103 | 0 | 0 | 45 | 0 | 10 | 12 | 0 | 0 | 0 | 40 | 0 | |
| 104 | 0 | 0 | 44 | 0 | 11 | 11 | 0 | 0 | 0 | 41 | 0 | |
| 105 | 0 | 0 | 18 | 17 | 12 | 10 | 0 | 0 | 0 | 42 | 0 | |
| 106 | 0 | 0 | 17 | 0 | 13 | 9 | 0 | 0 | 0 | 43 | 0 | |
| 107 | 0 | 0 | 0 | 0 | 14 | 8 | 0 | 0 | 0 | 44 | 0 | |
| 108 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 22 | 0 | |
| 109 | 40 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 23 | 0 | |
| ⋮ | | | | | | | | | | | | |

```
reward = [time_index_vector', reward_matrix]
```

reward = 31×26

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ⋯ |
| 101 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 102 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | |
| 103 | 0 | 0 | -1 | 0 | -1 | -1 | 0 | 0 | 0 | -1 | 0 | |
| 104 | 0 | 0 | -15 | 0 | -1 | -1 | 0 | 0 | 0 | -1 | 0 | |
| 105 | 0 | 0 | 100 | 0 | -1 | -1 | 0 | 0 | 0 | -1 | 0 | |
| 106 | 0 | 0 | 0 | 0 | -1 | 100 | 0 | 0 | 0 | -1 | 0 | |
| 107 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | -15 | 0 | |
| 108 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 100 | 0 | |
| 109 | -15 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | |
| ⋮ | | | | | | | | | | | | |

```
cumulative_reward = [time_index_vector', cumulative_reward_matrix]
```

cumulative_reward = 31×26

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ⋯ |
| 101 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 102 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | |
| 103 | 0 | 0 | -1 | 0 | -1 | -2 | 0 | 0 | 0 | -1 | 0 | |
| 104 | 0 | 0 | -16 | 0 | -2 | -3 | 0 | 0 | 0 | -2 | 0 | |
| 105 | 0 | 0 | 84 | 0 | -3 | -4 | 0 | 0 | 0 | -3 | 0 | |
| 106 | 0 | 0 | 84 | 0 | -4 | 96 | 0 | 0 | 0 | -4 | 0 | |
| 107 | 0 | 0 | 0 | 0 | -5 | 96 | 0 | 0 | 0 | -19 | 0 | |
| 108 | 0 | 0 | 0 | 0 | -6 | 0 | 0 | 0 | 0 | 81 | 0 | |
| 109 | -15 | 0 | 0 | 0 | 94 | 0 | 0 | 0 | 0 | 81 | 0 | |

```
state_value = [time_index_vector', state_value_matrix]
```

```
state_value = 31×26
  100.0000         0         0         0         0         0         0         0 ···
  101.0000         0         0         0         0         0         0         0
  102.0000         0         0         0         0         0   58.5000         0
  103.0000         0         0   61.5000         0   41.5000   67.0000         0
  104.0000         0         0   70.0000         0   50.0000   75.5000         0
  105.0000         0         0   92.5000         0   58.5000   84.0000         0
  106.0000         0         0         0         0   67.0000   92.5000         0
  107.0000         0         0         0         0   75.5000         0         0
  108.0000         0         0         0         0   84.0000         0         0
  109.0000   70.0000         0         0         0   92.5000         0         0
     ⋮
```

```
action_value = [time_index_vector', action_value_matrix]
```

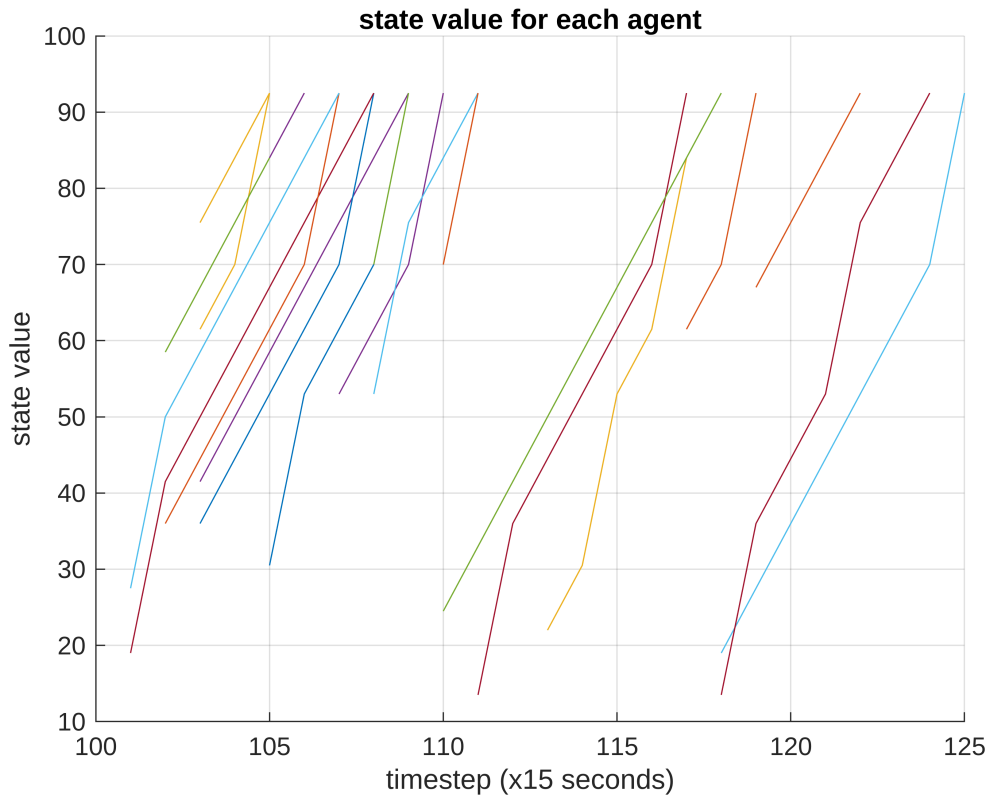
```
action_value = 31×26
  100.0000         0         0         0         0         0         0         0 ···
  101.0000         0         0         0         0         0         0         0
  102.0000         0         0         0         0         0   58.5000         0
  103.0000         0         0   61.5000         0   41.5000   67.0000         0
  104.0000         0         0   70.0000         0   50.0000   75.5000         0
  105.0000         0         0   92.5000         0   58.5000   84.0000         0
  106.0000         0         0         0         0   67.0000   92.5000         0
  107.0000         0         0         0         0   75.5000         0         0
  108.0000         0         0         0         0   84.0000         0         0
  109.0000   70.0000         0         0         0   92.5000         0         0
     ⋮
```

## VII. Result Graph

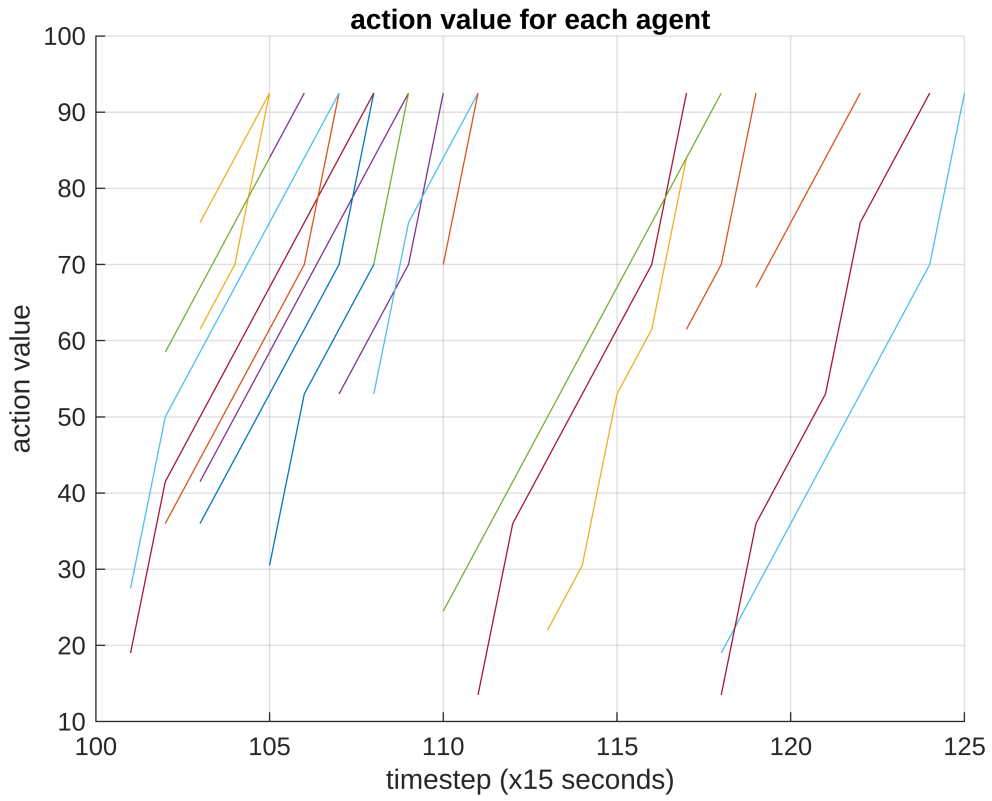
```
number_of_agents = length(agents_input(:,1));

figure;
hold on
for agent_index = 1:number_of_agents

    cumulative_reward_each_agent = [time_index_vector',
cumulative_reward_matrix(:,agent_index)];
    cumulative_reward_each_agent =
cumulative_reward_each_agent(cumulative_reward_each_agent(:,2) ~= 0, :);

   plot(cumulative_reward_each_agent(:,1),cumulative_reward_each_agent(:,2))

end
hold off
grid on
title('cumulative reward for each agent')
```

```
xlabel('timestep (x15 seconds)')
ylabel('cumulative reward')
```


```
figure;
hold on
for agent_index = 1:number_of_agents

    state_value_each_agent = [time_index_vector',
state_value_matrix(:,agent_index)];
    state_value_each_agent =
state_value_each_agent(state_value_each_agent(:,2) ~= 0, :);

    plot(state_value_each_agent(:,1),state_value_each_agent(:,2))
end
hold off
grid on
title('state value for each agent')
xlabel('timestep (x15 seconds)')
ylabel('state value')
```




```
figure;
hold on
for agent_index = 1:number_of_agents

    action_value_each_agent = [time_index_vector',
action_value_matrix(:,agent_index)];
    action_value_each_agent =
action_value_each_agent(action_value_each_agent(:,2) ~= 0, :);
    plot(action_value_each_agent(:,1),action_value_each_agent(:,2))
end
hold off
grid on
title('action value for each agent')
xlabel('timestep (x15 seconds)')
ylabel('action value')
```




```
figure;
hold on
for agent_index = 1:number_of_agents

    state_value_each_agent = [time_index_vector',
state_value_matrix(:,agent_index)];
    state_value_each_agent =
state_value_each_agent(state_value_each_agent(:,2) ~= 0, :);


plot(state_value_each_agent(:,1),state_value_each_agent(:,2),'b','LineWidth',
2)
end


for agent_index = 1:number_of_agents

    action_value_each_agent = [time_index_vector',
action_value_matrix(:,agent_index)];
    action_value_each_agent =
action_value_each_agent(action_value_each_agent(:,2) ~= 0, :);
```

```
plot(action_value_each_agent(:,1),action_value_each_agent(:,2),'r','LineWidth
',1)
end
hold off
grid on
title('State(blue) and Action(red) Value Combined')
xlabel('timestep (x15 seconds)')
ylabel('state/action value')
```