RS-HL-11: Multi User Sequential Simulation

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I. Load the SAT-to-SAT 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

```
% Parameter Setting
time_index_vector = 100:130;
start_time_index = 100:120;
state_vector = 1:48;

start_state = [3,3,3,3];
destination_state = [38, 38, 38, 38];
start_time = [100, 100, 100, 100];

simulation_input = [start_time', start_state', destination_state'];
number_of_simulation = length(simulation_input(:,1));
```

III. Run the MDP simulation

```
simulation_result = struct();
MDP = struct();

for simulation_index = 1:number_of_simulation

    if simulation_index == 1
        sat_to_sat_matrix = sat_to_sat_contact_3d_matrix;
    else
        sat_to_sat_matrix = sat_to_sat_matrix_updated;
    end

    % Run the MDP
```

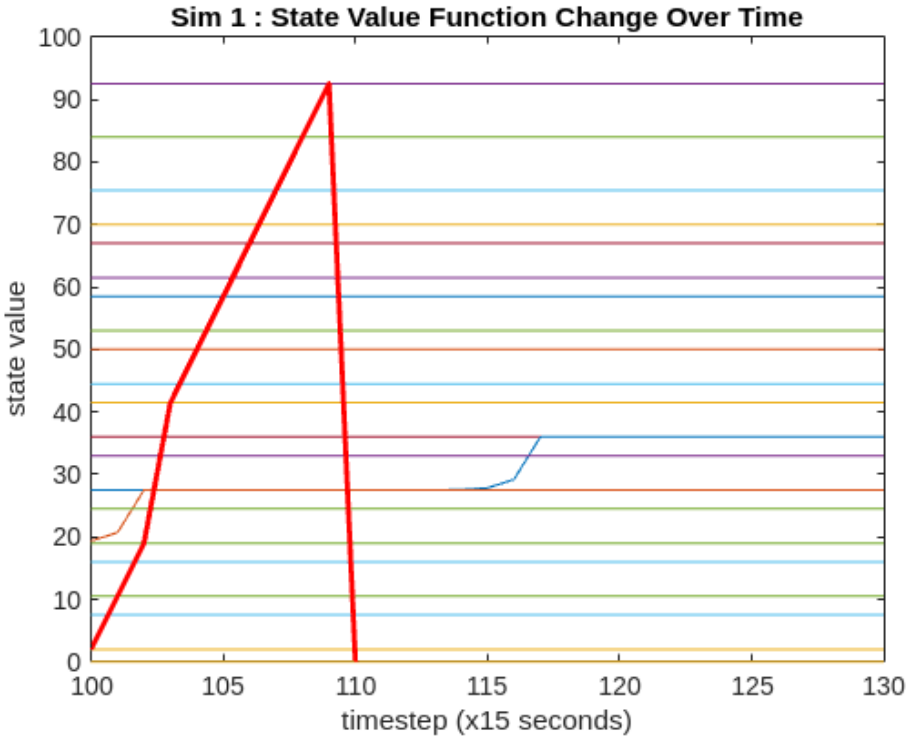
```
    MDP.(['MDP',num2str(simulation_index)]) = runMDP(sat_to_sat_matrix,
time_index_vector,destination_state(simulation_index));
    [time_list, reward_list, state_list, state_value_list]=
simulation_test(start_time(simulation_index),start_state(simulation_index),
MDP.
(['MDP',num2str(simulation_index)]),time_index_vector,destination_state(simul
ation_index));

    % Record ths simulation result
    simulation_result.(['simulation',num2str(simulation_index)]).result =
[time_list,  state_list,reward_list, state_value_list];



    number_of_states = length(state_vector);
    state_value_over_time =
zeros(length(time_index_vector),number_of_states);
    for t = 1:length(time_index_vector)
        for state_index = 1:number_of_states
            state_value_over_time(t,state_index) = MDP.
(['MDP',num2str(simulation_index)]).(['time' num2str(time_index_vector(t))]).
(['state' num2str(state_index)]).('state_value');
        end
    end

    simulation_result.
(['simulation',num2str(simulation_index)]).state_value_over_time =
state_value_over_time;


    % Update the sat_to_sat_matrix
    sat_to_sat_matrix_updated = sat_to_sat_matrix;

    for index = 2:length(time_list)

    time_index = time_list(index);
    state_index = state_list(index);

    % sat_to_sat_matrix_updated(state_index,:,time_index) = 0;
    sat_to_sat_matrix_updated(:,state_index,time_index-1) = 0;
    % sat_to_sat_matrix_updated(state_index,state_index,time_index) = 1;

    % sat_to_sat_matrix_updated(state_index,:,time_index+1) = 0;
    % sat_to_sat_matrix_updated(:,state_index,time_index+1) = 0;
    % sat_to_sat_matrix_updated(state_index,state_index,time_index+1) = 1;
    end

end
```

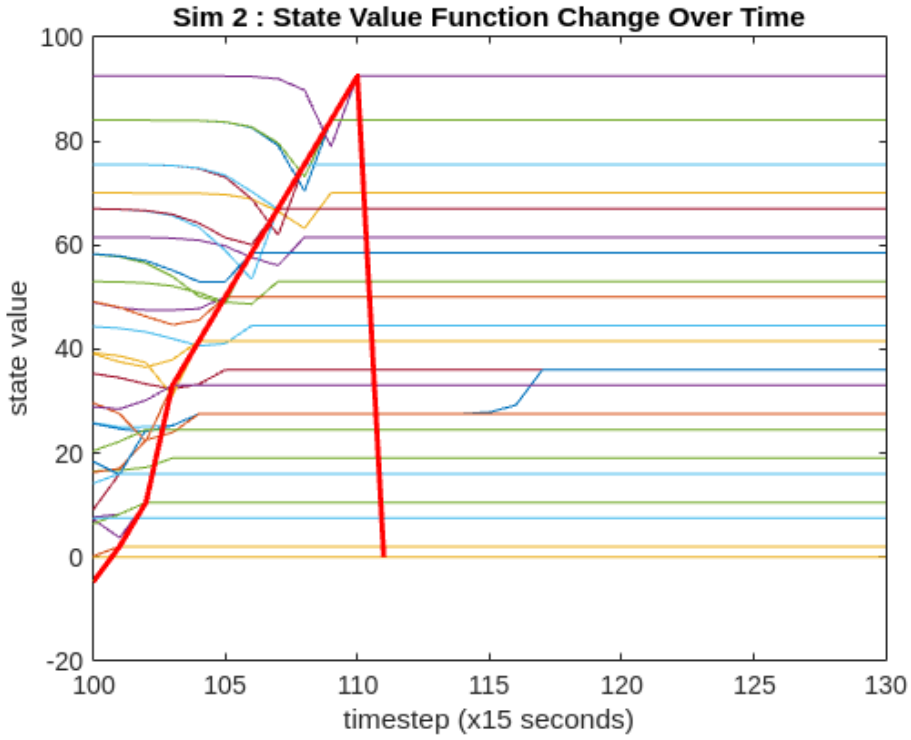
```
simulation set up complete!
Policy: 1 -> Value Iteration: 460
Policy: 2 -> Value Iteration: 14
Policy: 3 -> Value Iteration: 5
Policy: 4 -> Value Iteration: 5
Policy: 5 -> Value Iteration: 8
Policy: 6 -> Value Iteration: 10
Policy: 7 -> Value Iteration: 9
Policy: 8 -> Value Iteration: 1
Policy: 9 -> Value Iteration: 1
Policy: 10 -> Value Iteration: 1
Policy: 11 -> Value Iteration: 1
simulation set up complete!
Policy: 1 -> Value Iteration: 460
Policy: 2 -> Value Iteration: 14
Policy: 3 -> Value Iteration: 5
Policy: 4 -> Value Iteration: 5
Policy: 5 -> Value Iteration: 8
Policy: 6 -> Value Iteration: 10
Policy: 7 -> Value Iteration: 9
Policy: 8 -> Value Iteration: 1
Policy: 9 -> Value Iteration: 1
Policy: 10 -> Value Iteration: 1
Policy: 11 -> Value Iteration: 1
simulation set up complete!
Policy: 1 -> Value Iteration: 460
Policy: 2 -> Value Iteration: 14
Policy: 3 -> Value Iteration: 5
Policy: 4 -> Value Iteration: 5
Policy: 5 -> Value Iteration: 8
Policy: 6 -> Value Iteration: 10
Policy: 7 -> Value Iteration: 9
Policy: 8 -> Value Iteration: 1
Policy: 9 -> Value Iteration: 1
Policy: 10 -> Value Iteration: 1
Policy: 11 -> Value Iteration: 1
simulation set up complete!
Policy: 1 -> Value Iteration: 460
Policy: 2 -> Value Iteration: 14
Policy: 3 -> Value Iteration: 5
Policy: 4 -> Value Iteration: 5
Policy: 5 -> Value Iteration: 8
Policy: 6 -> Value Iteration: 10
Policy: 7 -> Value Iteration: 9
Policy: 8 -> Value Iteration: 1
Policy: 9 -> Value Iteration: 1
Policy: 10 -> Value Iteration: 1
Policy: 11 -> Value Iteration: 1
```

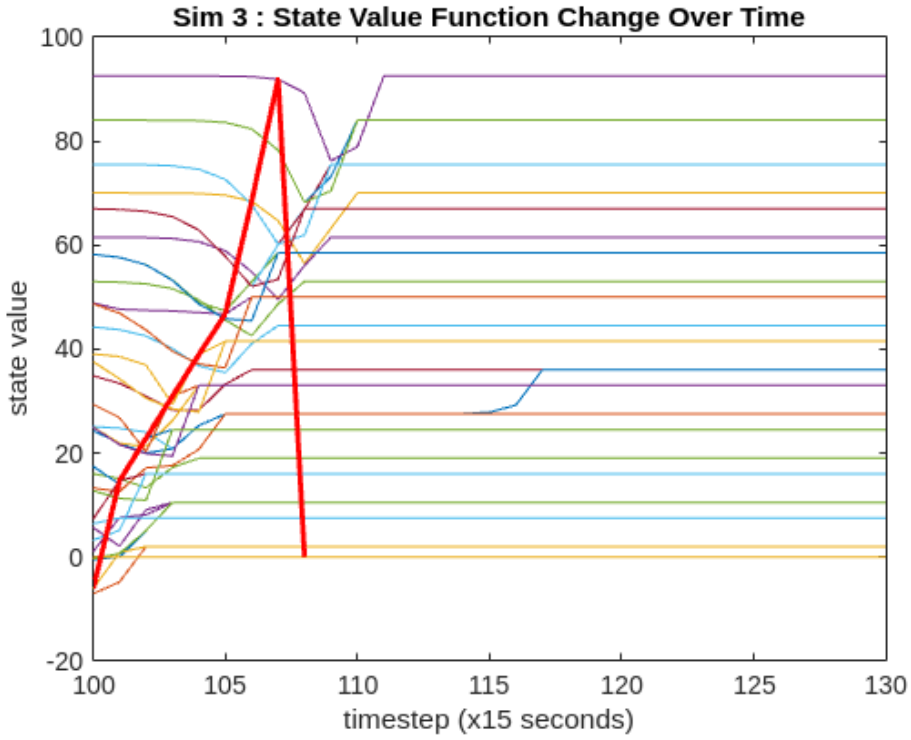
III. State Value changing over time

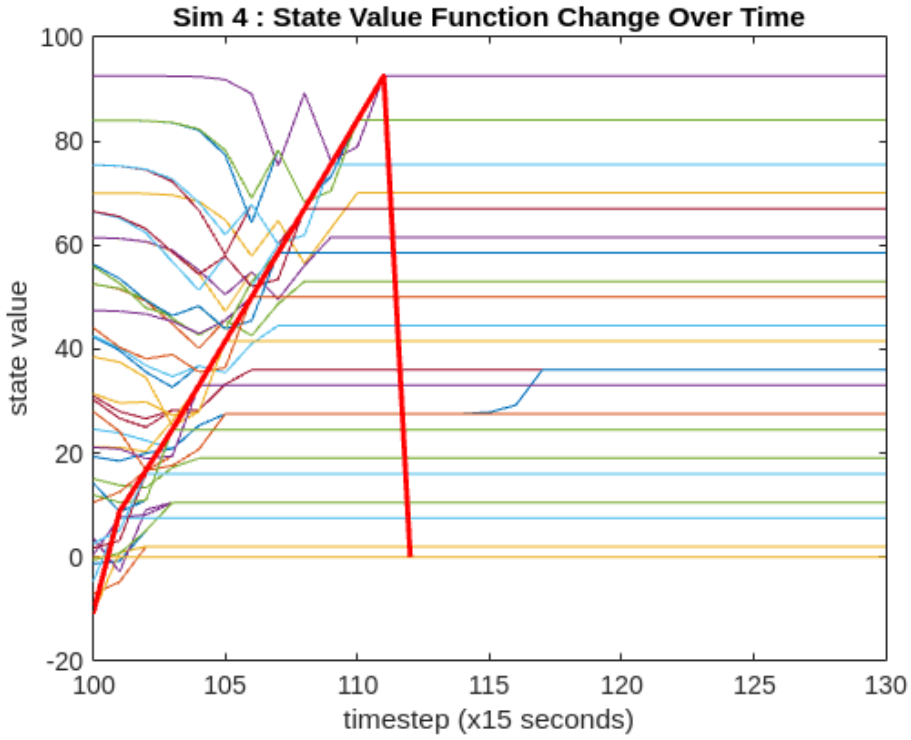
```
for simulation_index = 1:number_of_simulation

    figure;
    for state_index = 1:number_of_states
        plot(time_index_vector,simulation_result.
(['simulation',num2str(simulation_index)]).state_value_over_time(:,state_inde
x))
```

```
        hold on
    end

    result = simulation_result.
(['simulation',num2str(simulation_index)]).result;
    plot(result(:,1),result(:,4),'r','LineWidth',2)

    hold off
    title(sprintf('Sim %d : State Value Function Change Over
Time',simulation_index))
    xlabel('timestep (x15 seconds)')
    ylabel('state value')

end
```



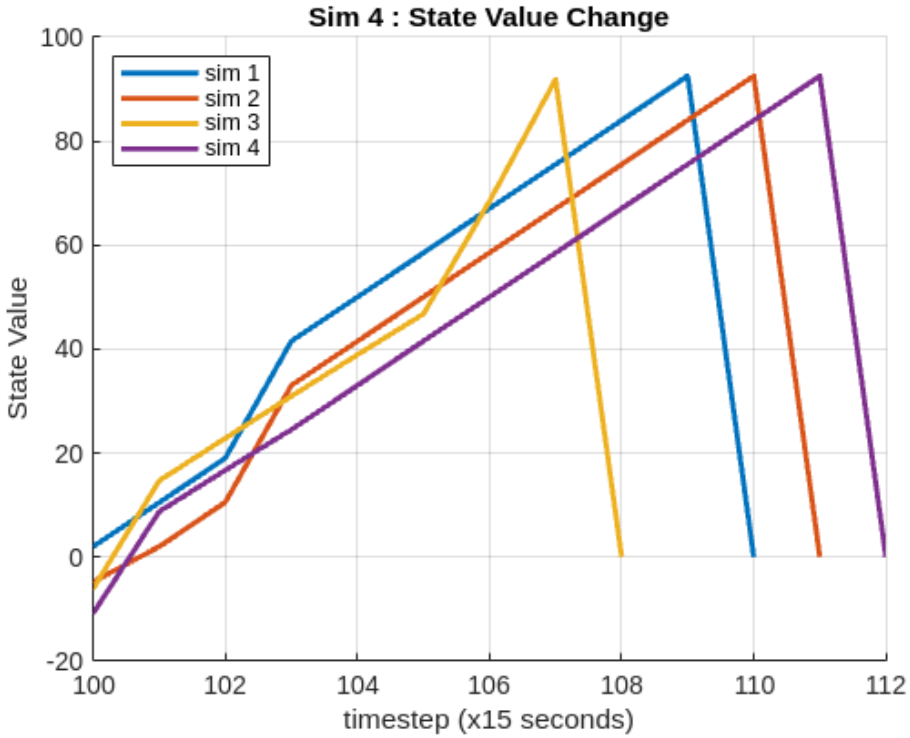

Sim 2 : State Value Function Change Over Time
state value
timestep (x15 seconds)
100
80
60
40
20
0
-20
100
105
110
115
120
125
130


Sim 3 : State Value Function Change Over Time
state value
timestep (x15 seconds)
100
80
60
40
20
0
-20
100
105
110
115
120
125
130



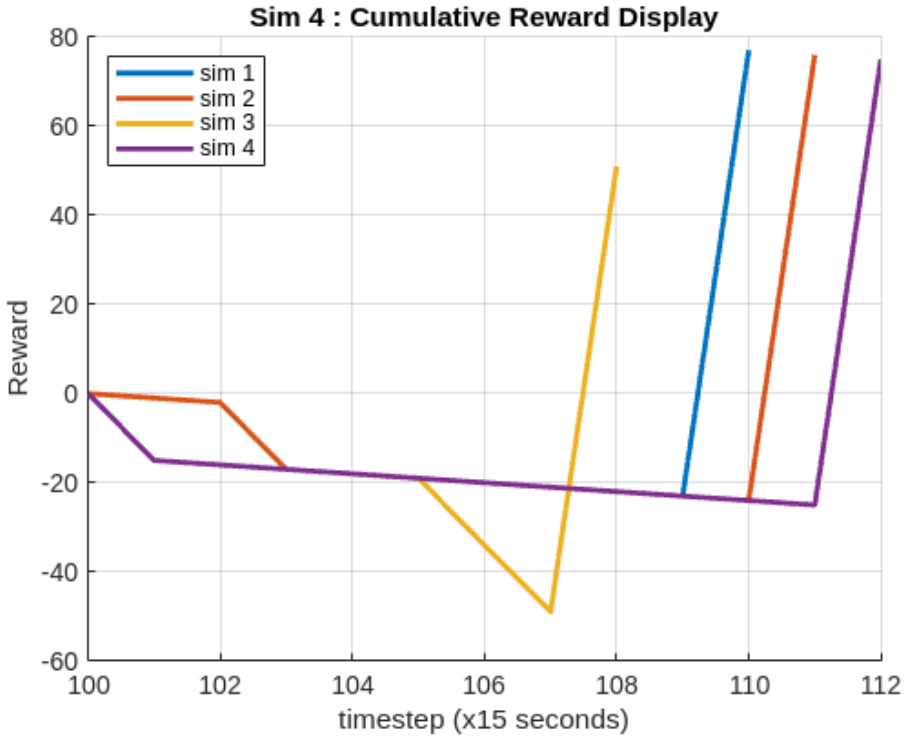
IV. State Value By Each Simulation

```
figure;
hold on
for simulation_index = 1:number_of_simulation
    result = simulation_result.
(['simulation',num2str(simulation_index)]).result;
    plot(result(:,1),result(:,4),'LineWidth',2,'DisplayName',sprintf('sim
%d', simulation_index))
end
hold off
title(sprintf('Sim %d : State Value Change',simulation_index))
grid on
xlabel('timestep (x15 seconds)')
ylabel('State Value')
legend('show','Location','northwest')
```



V. Reward Value By Each Simulation

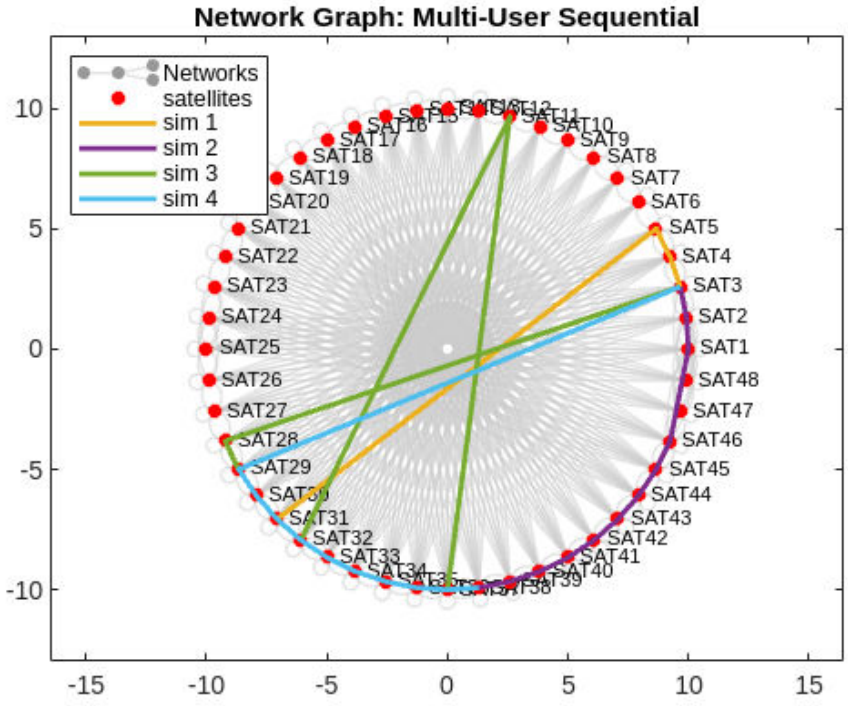
```
figure;
hold on
for simulation_index = 1:number_of_simulation
    result = simulation_result.
(['simulation',num2str(simulation_index)]).result;
    plot(result(:,1),result(:,3),'LineWidth',2,'DisplayName',sprintf('sim
%d', simulation_index))
end
hold off
title(sprintf('Sim %d : Cumulative Reward Display',simulation_index))
grid on
xlabel('timestep (x15 seconds)')
ylabel('Reward')
legend('show','Location','northwest')
```



VI. Data Plot on the Network

```
% Number of ground stations and satellites
num_sats = 48;

% Create a graph object
G = graph();

% Load the Satellite Contact Matrix
Sat_to_Sat = sat_to_sat_contact_3d_matrix(:,:,time_index);

% Add Satellites as nodes
for i = 1:num_sats
    G = addnode(G, sprintf('SAT%d', i));
end


% Add edges between Satellites
for i = 1:num_sats
    for j = 1:num_sats
        if Sat_to_Sat(i, j) == 1
            G = addedge(G, sprintf('SAT%d', i), sprintf('SAT%d', j));
        end
    end
end
```

```
pi = 3.1415026535;
satellite_radius = 10;

% Satellite positions
satellite_angles = linspace(0, 2*pi, num_sats+1);
satellite_angles = satellite_angles(1:end-1);
satellite_x = satellite_radius * cos(satellite_angles);
satellite_y = satellite_radius * sin(satellite_angles);

% Plot the network graph
figure;
plot(G, 'XData', satellite_x, 'YData', satellite_y, 'NodeColor', [0.6 0.6
0.6], 'EdgeColor', [0.8 0.8 0.8], 'LineWidth', 1,'DisplayName','Networks');
hold on;
% Plot the ground stations in blue and the satellites in red
plot(satellite_x, satellite_y, 'ro', 'MarkerSize', 5, 'MarkerFaceColor',
'r','DisplayName','satellites');

for simulation_index = 1:number_of_simulation

sim_result = simulation_result.
(['simulation',num2str(simulation_index)]).result;

Data_Transmission_Sequence = zeros(length(sim_result(:,1)),2);

    for ii = 1:length(sim_result(:,1))
        Data_Transmission_Sequence(ii,:) = [satellite_x(sim_result(ii,2)),
satellite_y(sim_result(ii,2))];
    end


plot(Data_Transmission_Sequence(:,1),Data_Transmission_Sequence(:,2),'LineWid
th',2,'DisplayName',sprintf('sim %d', simulation_index));

end


hold off
legend('show','location','northwest')
% Adjust the axis limits to fit the plot
axis equal;
title('Network Graph: Multi-User Sequential');
```


Network Graph: Multi-User Sequential
Networks
satellites
sim 1
sim 2
sim 3
sim 4
SAT1
SAT2
SAT3
SAT4
SAT5
SAT6
SAT7
SAT8
SAT9
SAT10
SAT11
SAT17
SAT18
SAT19
SAT20
SAT21
SAT22
SAT23
SAT24
SAT25
SAT26
SAT27
SAT28
SAT29
SAT31
SAT32
SAT33
SAT41
SAT42
SAT43
SAT44
SAT45
SAT46
SAT47
SAT48
10
5
0
-5
-10
-15
-10
-5
0
5
10
15