

-----Mandatory Information to fill-----

Group ID: Group 150

Group Members Name with Student ID:

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-----Write your remarks (if any) that you want should get consider at the time of evaluation-----

Remarks: ##Add here

Background

In digital advertising, Click-Through Rate (CTR) is a critical metric that measures the effectiveness of an advertisement. It is calculated as the ratio of users who click on an ad to the number of users who view the ad. A higher CTR indicates more successful engagement with the audience, which can lead to increased conversions and revenue. From time-to-time advertisers experiment with various elements/targeting of an ad to optimise the ROI.

Scenario

Imagine an innovative digital advertising agency, AdMasters Inc., that specializes in maximizing click-through rates (CTR) for their clients' advertisements. One of their clients has identified four key tunable elements in their ads: *Age*, *City*, *Gender*, and *Mobile Operating System (OS)*. These elements significantly influence user engagement and conversion rates. The client is keen to optimize their CTR while minimizing resource expenditure.

Objective

Optimize the CTR of digital ads by employing Multi Arm Bandit algorithms. System should dynamically and efficiently allocate ad displays to maximize overall CTR.

Dataset

The dataset for Ads contains 4 unique features/characteristics.

- Age (Range: 25:50)

- City (Possible Values: 'New York', 'Los Angeles', 'Chicago', 'Houston', 'Phoenix')
- Gender (Possible Values: 'Male', 'Female')
- OS: (Possible Values: 'iOS', 'Android', 'Other')

Link for accessing dataset: <https://drive.google.com/file/d/1Y5HmEeoQsafo9Diy9piS69qEMnC0g1ys/view?usp=sharing>

Environment Details

Arms: Each arm represents a different ad from the dataset.

Reward Function:

- Probability of a Male clicking on an Ad -> 0.7 (randomly generated)
- Probability of a Female clicking on an Ad -> 0.6 (randomly generated)
- Once probabilities are assigned to all the values, create a final reward (clicked or not clicked binary outcome) based on the assumed probabilities in step 1 (by combining the probabilities of each feature value present in that ad)

Assumptions

- Assume $\alpha = \beta = 1$ for cold start
- Explore Percentage = 10%
- Run the simulation for min 1000 iterations

Requirements and Deliverables:

Implement the Multi-Arm Bandit Problem for the given above scenario for all the below mentioned policy methods.

Initialize constants

```
In [ ]: !pip install pandas
        !pip install numpy
        !pip install matplotlib
        !pip install python-math
```

Requirement already satisfied: pandas in /usr/local/lib/python3.10/dist-packages (2.0.3)
 Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.10/dist-packages (from pandas) (2.8.2)
 Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas) (2023.4)
 Requirement already satisfied: tzdata>=2022.1 in /usr/local/lib/python3.10/dist-packages (from pandas) (2024.1)
 Requirement already satisfied: numpy>=1.21.0 in /usr/local/lib/python3.10/dist-packages (from pandas) (1.25.2)
 Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.2->pandas) (1.16.0)
 Requirement already satisfied: numpy in /usr/local/lib/python3.10/dist-packages (1.25.2)
 Requirement already satisfied: matplotlib in /usr/local/lib/python3.10/dist-packages (3.7.1)
 Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib) (1.2.1)
 Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.10/dist-packages (from matplotlib) (0.12.1)
 Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib) (4.53.0)
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 Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib) (24.1)
 Requirement already satisfied: pillow>=6.2.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib) (9.4.0)
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 Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.10/dist-packages (from matplotlib) (2.8.2)
 Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.7->matplotlib) (1.16.0)
 Collecting python-math
 Downloading python_math-0.0.1-py3-none-any.whl (2.4 kB)
 Installing collected packages: python-math
 Successfully installed python-math-0.0.1

```
In [ ]: # Constants
epsilon = 0.1 # Default exploration percentage for epsilon-greedy
num_iterations = 1000 # Number of iterations to run for each policy
alpha = 1 # Parameter for initialization in UCB algorithm
```

Load Dataset

```
In [ ]: # Code for Dataset Loading and print dataset statistics
#-----write your code below this line-----
import pandas as pd

file_path = '/content/sample_data/AD_Click.csv'
df = pd.read_csv(file_path)

# Print dataset statistics
print("Dataset Statistics:")
print(df.describe())
```

Dataset Statistics:

	Age
count	780.000000
mean	37.500000
std	7.504812
min	25.000000
25%	31.000000
50%	37.500000
75%	44.000000
max	50.000000

Design a CTR Environment (1M)

```
In [ ]: # Code for Dataset Loading and print dataset statistics along with reward function
#-----write your code below this line-----
import pandas as pd
import numpy as np
import random
import matplotlib.pyplot as plt

# Example code for creating CTR environment class
# Define CTR Environment class
class CTREnvironment:
    def __init__(self, dataset):
        self.dataset = dataset
        self.total_ads = len(dataset)
        self.iterations = 0
        self.action_counts = np.zeros(len(dataset))

    # Reward function - simulates a click reward for an ad based on its
    # index and the given action, using predefined click probabilities.
    def get_reward(self, ad_index, action):
        # Example reward function (replace with your actual reward logic)
        ad = self.dataset.iloc[ad_index]
        if action == 'Male':
            click_prob = 0.7 # Example click probability for Male
        elif action == 'Female':
            click_prob = 0.6 # Example click probability for Female
        else:
            click_prob = 0.5 # Default click probability for other actions

        # Simulate click based on click probability
        if random.random() < click_prob:
            return 1 # Clicked
        else:
            return 0 # Not clicked

    # The run function simulates a multi-armed bandit problem over num_iterations,
    # selecting actions based on a given policy, collecting rewards, and tracking
    # average rewards over time. It prints details of each iteration and returns
    # the list of average rewards.
    def run(self, policy, num_iterations, epsilon=epsilon):
        rewards = []
        avg_rewards = []
        for _ in range(num_iterations):
            ad_index = random.randint(0, self.total_ads - 1)
            action = policy(self, ad_index)
            self.action_counts[ad_index] += 1
            reward = self.get_reward(ad_index, action)
            rewards.append(reward)
            self.iterations += 1
```

```

        avg_reward = np.mean(rewards)
        avg_rewards.append(avg_reward)
        # Print current iteration details
        print(f"Iteration {self.iterations}: Policy={policy.__name__},
              Ad={ad_index}, Action={action}, Reward={reward}")
    return avg_rewards

# usage:
if __name__ == "__main__":
    # Initialize environment with the dataset
    env = CTREnvironment(df)

    print(df.describe())
    # usage of reward function
    ad_index = random.randint(0, len(env.dataset) - 1)
    action = 'Male' # action
    reward = env.get_reward(ad_index, action)
    print(f"\nReward for Ad {ad_index} with action '{action}': {reward}")

```

```

          Age
count  100.000000
mean    37.080000
std      7.934937
min     25.000000
25%     30.000000
50%     37.000000
75%     44.000000
max     50.000000

```

Reward for Ad 10 with action 'Male': 1

Using Random Policy (0.5M)

Print all the iterations with random policy selected for the given Ad. (Mandatory)

```

In [ ]: # run the environment with an agent that is guided by a random policy
#-----write your code below this line-----
# Random policy
def random_policy(env, ad_index):
    return random.choice(['Male', 'Female'])

# Run each policy and store rewards
random_rewards = env.run(random_policy, num_iterations)

```

Iteration 1: Policy=random_policy, Ad=46, Action=Female, Reward=1
Iteration 2: Policy=random_policy, Ad=72, Action=Female, Reward=0
Iteration 3: Policy=random_policy, Ad=98, Action=Female, Reward=1
Iteration 4: Policy=random_policy, Ad=89, Action=Male, Reward=0
Iteration 5: Policy=random_policy, Ad=73, Action=Male, Reward=0
Iteration 6: Policy=random_policy, Ad=2, Action=Female, Reward=1
Iteration 7: Policy=random_policy, Ad=37, Action=Female, Reward=0
Iteration 8: Policy=random_policy, Ad=46, Action=Female, Reward=0
Iteration 9: Policy=random_policy, Ad=57, Action=Male, Reward=0
Iteration 10: Policy=random_policy, Ad=41, Action=Male, Reward=0
Iteration 11: Policy=random_policy, Ad=18, Action=Female, Reward=1
Iteration 12: Policy=random_policy, Ad=2, Action=Female, Reward=0
Iteration 13: Policy=random_policy, Ad=32, Action=Male, Reward=0
Iteration 14: Policy=random_policy, Ad=36, Action=Female, Reward=1
Iteration 15: Policy=random_policy, Ad=71, Action=Male, Reward=1
Iteration 16: Policy=random_policy, Ad=21, Action=Female, Reward=0
Iteration 17: Policy=random_policy, Ad=59, Action=Female, Reward=1
Iteration 18: Policy=random_policy, Ad=63, Action=Female, Reward=0
Iteration 19: Policy=random_policy, Ad=46, Action=Female, Reward=1
Iteration 20: Policy=random_policy, Ad=73, Action=Female, Reward=1
Iteration 21: Policy=random_policy, Ad=46, Action=Male, Reward=0
Iteration 22: Policy=random_policy, Ad=26, Action=Male, Reward=1
Iteration 23: Policy=random_policy, Ad=89, Action=Male, Reward=1
Iteration 24: Policy=random_policy, Ad=49, Action=Male, Reward=0
Iteration 25: Policy=random_policy, Ad=63, Action=Female, Reward=0
Iteration 26: Policy=random_policy, Ad=17, Action=Female, Reward=0
Iteration 27: Policy=random_policy, Ad=10, Action=Male, Reward=1
Iteration 28: Policy=random_policy, Ad=36, Action=Male, Reward=1
Iteration 29: Policy=random_policy, Ad=66, Action=Male, Reward=1
Iteration 30: Policy=random_policy, Ad=90, Action=Male, Reward=0
Iteration 31: Policy=random_policy, Ad=21, Action=Female, Reward=1
Iteration 32: Policy=random_policy, Ad=3, Action=Male, Reward=1
Iteration 33: Policy=random_policy, Ad=32, Action=Female, Reward=0
Iteration 34: Policy=random_policy, Ad=25, Action=Female, Reward=0
Iteration 35: Policy=random_policy, Ad=49, Action=Male, Reward=1
Iteration 36: Policy=random_policy, Ad=40, Action=Female, Reward=1
Iteration 37: Policy=random_policy, Ad=62, Action=Female, Reward=1
Iteration 38: Policy=random_policy, Ad=1, Action=Female, Reward=0
Iteration 39: Policy=random_policy, Ad=24, Action=Female, Reward=0
Iteration 40: Policy=random_policy, Ad=93, Action=Male, Reward=1
Iteration 41: Policy=random_policy, Ad=58, Action=Female, Reward=1
Iteration 42: Policy=random_policy, Ad=48, Action=Male, Reward=1
Iteration 43: Policy=random_policy, Ad=60, Action=Female, Reward=0
Iteration 44: Policy=random_policy, Ad=90, Action=Male, Reward=0
Iteration 45: Policy=random_policy, Ad=22, Action=Female, Reward=1
Iteration 46: Policy=random_policy, Ad=5, Action=Female, Reward=1
Iteration 47: Policy=random_policy, Ad=20, Action=Female, Reward=0
Iteration 48: Policy=random_policy, Ad=13, Action=Female, Reward=0
Iteration 49: Policy=random_policy, Ad=35, Action=Male, Reward=1
Iteration 50: Policy=random_policy, Ad=55, Action=Male, Reward=1
Iteration 51: Policy=random_policy, Ad=15, Action=Male, Reward=1
Iteration 52: Policy=random_policy, Ad=15, Action=Male, Reward=0
Iteration 53: Policy=random_policy, Ad=90, Action=Female, Reward=0
Iteration 54: Policy=random_policy, Ad=22, Action=Female, Reward=1
Iteration 55: Policy=random_policy, Ad=66, Action=Female, Reward=0
Iteration 56: Policy=random_policy, Ad=25, Action=Female, Reward=1
Iteration 57: Policy=random_policy, Ad=92, Action=Female, Reward=0
Iteration 58: Policy=random_policy, Ad=62, Action=Female, Reward=0
Iteration 59: Policy=random_policy, Ad=7, Action=Female, Reward=0
Iteration 60: Policy=random_policy, Ad=5, Action=Male, Reward=1
Iteration 61: Policy=random_policy, Ad=11, Action=Female, Reward=0
Iteration 62: Policy=random_policy, Ad=52, Action=Female, Reward=1
Iteration 63: Policy=random_policy, Ad=95, Action=Female, Reward=1
Iteration 64: Policy=random_policy, Ad=33, Action=Female, Reward=1

Iteration 65: Policy=random_policy, Ad=56, Action=Female, Reward=0
Iteration 66: Policy=random_policy, Ad=57, Action=Male, Reward=1
Iteration 67: Policy=random_policy, Ad=1, Action=Female, Reward=1
Iteration 68: Policy=random_policy, Ad=99, Action=Female, Reward=0
Iteration 69: Policy=random_policy, Ad=62, Action=Female, Reward=1
Iteration 70: Policy=random_policy, Ad=84, Action=Female, Reward=1
Iteration 71: Policy=random_policy, Ad=70, Action=Female, Reward=1
Iteration 72: Policy=random_policy, Ad=32, Action=Male, Reward=1
Iteration 73: Policy=random_policy, Ad=77, Action=Female, Reward=1
Iteration 74: Policy=random_policy, Ad=62, Action=Male, Reward=0
Iteration 75: Policy=random_policy, Ad=14, Action=Male, Reward=1
Iteration 76: Policy=random_policy, Ad=78, Action=Female, Reward=1
Iteration 77: Policy=random_policy, Ad=96, Action=Female, Reward=1
Iteration 78: Policy=random_policy, Ad=27, Action=Male, Reward=1
Iteration 79: Policy=random_policy, Ad=99, Action=Male, Reward=0
Iteration 80: Policy=random_policy, Ad=91, Action=Male, Reward=0
Iteration 81: Policy=random_policy, Ad=5, Action=Female, Reward=1
Iteration 82: Policy=random_policy, Ad=70, Action=Male, Reward=1
Iteration 83: Policy=random_policy, Ad=79, Action=Female, Reward=0
Iteration 84: Policy=random_policy, Ad=75, Action=Female, Reward=1
Iteration 85: Policy=random_policy, Ad=69, Action=Male, Reward=1
Iteration 86: Policy=random_policy, Ad=15, Action=Male, Reward=0
Iteration 87: Policy=random_policy, Ad=48, Action=Male, Reward=1
Iteration 88: Policy=random_policy, Ad=88, Action=Male, Reward=0
Iteration 89: Policy=random_policy, Ad=49, Action=Male, Reward=0
Iteration 90: Policy=random_policy, Ad=14, Action=Female, Reward=1
Iteration 91: Policy=random_policy, Ad=95, Action=Female, Reward=1
Iteration 92: Policy=random_policy, Ad=67, Action=Female, Reward=0
Iteration 93: Policy=random_policy, Ad=90, Action=Male, Reward=1
Iteration 94: Policy=random_policy, Ad=61, Action=Female, Reward=1
Iteration 95: Policy=random_policy, Ad=87, Action=Female, Reward=0
Iteration 96: Policy=random_policy, Ad=56, Action=Male, Reward=1
Iteration 97: Policy=random_policy, Ad=90, Action=Male, Reward=0
Iteration 98: Policy=random_policy, Ad=95, Action=Female, Reward=0
Iteration 99: Policy=random_policy, Ad=74, Action=Male, Reward=1
Iteration 100: Policy=random_policy, Ad=65, Action=Male, Reward=1
Iteration 101: Policy=random_policy, Ad=24, Action=Male, Reward=1
Iteration 102: Policy=random_policy, Ad=61, Action=Female, Reward=1
Iteration 103: Policy=random_policy, Ad=60, Action=Male, Reward=1
Iteration 104: Policy=random_policy, Ad=86, Action=Male, Reward=1
Iteration 105: Policy=random_policy, Ad=66, Action=Female, Reward=0
Iteration 106: Policy=random_policy, Ad=99, Action=Male, Reward=1
Iteration 107: Policy=random_policy, Ad=41, Action=Male, Reward=1
Iteration 108: Policy=random_policy, Ad=10, Action=Female, Reward=1
Iteration 109: Policy=random_policy, Ad=39, Action=Female, Reward=0
Iteration 110: Policy=random_policy, Ad=40, Action=Male, Reward=1
Iteration 111: Policy=random_policy, Ad=79, Action=Female, Reward=1
Iteration 112: Policy=random_policy, Ad=44, Action=Female, Reward=1
Iteration 113: Policy=random_policy, Ad=27, Action=Male, Reward=1
Iteration 114: Policy=random_policy, Ad=56, Action=Male, Reward=1
Iteration 115: Policy=random_policy, Ad=50, Action=Male, Reward=0
Iteration 116: Policy=random_policy, Ad=48, Action=Female, Reward=1
Iteration 117: Policy=random_policy, Ad=57, Action=Male, Reward=0
Iteration 118: Policy=random_policy, Ad=11, Action=Male, Reward=1
Iteration 119: Policy=random_policy, Ad=87, Action=Female, Reward=0
Iteration 120: Policy=random_policy, Ad=93, Action=Male, Reward=1
Iteration 121: Policy=random_policy, Ad=91, Action=Female, Reward=0
Iteration 122: Policy=random_policy, Ad=51, Action=Female, Reward=0
Iteration 123: Policy=random_policy, Ad=7, Action=Female, Reward=1
Iteration 124: Policy=random_policy, Ad=59, Action=Male, Reward=0
Iteration 125: Policy=random_policy, Ad=27, Action=Female, Reward=1
Iteration 126: Policy=random_policy, Ad=21, Action=Female, Reward=1
Iteration 127: Policy=random_policy, Ad=7, Action=Male, Reward=1
Iteration 128: Policy=random_policy, Ad=97, Action=Male, Reward=1

Iteration 129: Policy=random_policy, Ad=34, Action=Male, Reward=1
Iteration 130: Policy=random_policy, Ad=78, Action=Female, Reward=1
Iteration 131: Policy=random_policy, Ad=8, Action=Male, Reward=1
Iteration 132: Policy=random_policy, Ad=30, Action=Male, Reward=1
Iteration 133: Policy=random_policy, Ad=20, Action=Male, Reward=1
Iteration 134: Policy=random_policy, Ad=64, Action=Male, Reward=1
Iteration 135: Policy=random_policy, Ad=85, Action=Female, Reward=1
Iteration 136: Policy=random_policy, Ad=30, Action=Male, Reward=1
Iteration 137: Policy=random_policy, Ad=65, Action=Female, Reward=1
Iteration 138: Policy=random_policy, Ad=99, Action=Male, Reward=0
Iteration 139: Policy=random_policy, Ad=53, Action=Female, Reward=1
Iteration 140: Policy=random_policy, Ad=47, Action=Female, Reward=1
Iteration 141: Policy=random_policy, Ad=17, Action=Male, Reward=0
Iteration 142: Policy=random_policy, Ad=44, Action=Male, Reward=1
Iteration 143: Policy=random_policy, Ad=18, Action=Male, Reward=1
Iteration 144: Policy=random_policy, Ad=5, Action=Female, Reward=0
Iteration 145: Policy=random_policy, Ad=57, Action=Female, Reward=1
Iteration 146: Policy=random_policy, Ad=91, Action=Male, Reward=1
Iteration 147: Policy=random_policy, Ad=7, Action=Male, Reward=0
Iteration 148: Policy=random_policy, Ad=72, Action=Female, Reward=1
Iteration 149: Policy=random_policy, Ad=81, Action=Female, Reward=1
Iteration 150: Policy=random_policy, Ad=41, Action=Male, Reward=0
Iteration 151: Policy=random_policy, Ad=96, Action=Female, Reward=0
Iteration 152: Policy=random_policy, Ad=22, Action=Female, Reward=0
Iteration 153: Policy=random_policy, Ad=91, Action=Female, Reward=1
Iteration 154: Policy=random_policy, Ad=45, Action=Male, Reward=0
Iteration 155: Policy=random_policy, Ad=22, Action=Female, Reward=0
Iteration 156: Policy=random_policy, Ad=67, Action=Female, Reward=0
Iteration 157: Policy=random_policy, Ad=4, Action=Male, Reward=1
Iteration 158: Policy=random_policy, Ad=50, Action=Female, Reward=1
Iteration 159: Policy=random_policy, Ad=91, Action=Female, Reward=1
Iteration 160: Policy=random_policy, Ad=14, Action=Male, Reward=1
Iteration 161: Policy=random_policy, Ad=62, Action=Female, Reward=0
Iteration 162: Policy=random_policy, Ad=57, Action=Male, Reward=1
Iteration 163: Policy=random_policy, Ad=88, Action=Male, Reward=0
Iteration 164: Policy=random_policy, Ad=50, Action=Female, Reward=1
Iteration 165: Policy=random_policy, Ad=14, Action=Male, Reward=0
Iteration 166: Policy=random_policy, Ad=12, Action=Female, Reward=0
Iteration 167: Policy=random_policy, Ad=53, Action=Female, Reward=0
Iteration 168: Policy=random_policy, Ad=11, Action=Male, Reward=0
Iteration 169: Policy=random_policy, Ad=99, Action=Female, Reward=1
Iteration 170: Policy=random_policy, Ad=85, Action=Female, Reward=0
Iteration 171: Policy=random_policy, Ad=88, Action=Male, Reward=0
Iteration 172: Policy=random_policy, Ad=36, Action=Male, Reward=1
Iteration 173: Policy=random_policy, Ad=42, Action=Male, Reward=0
Iteration 174: Policy=random_policy, Ad=96, Action=Female, Reward=1
Iteration 175: Policy=random_policy, Ad=64, Action=Female, Reward=1
Iteration 176: Policy=random_policy, Ad=19, Action=Female, Reward=0
Iteration 177: Policy=random_policy, Ad=60, Action=Female, Reward=1
Iteration 178: Policy=random_policy, Ad=75, Action=Male, Reward=1
Iteration 179: Policy=random_policy, Ad=18, Action=Male, Reward=0
Iteration 180: Policy=random_policy, Ad=44, Action=Female, Reward=0
Iteration 181: Policy=random_policy, Ad=74, Action=Male, Reward=0
Iteration 182: Policy=random_policy, Ad=53, Action=Male, Reward=1
Iteration 183: Policy=random_policy, Ad=30, Action=Female, Reward=0
Iteration 184: Policy=random_policy, Ad=61, Action=Male, Reward=1
Iteration 185: Policy=random_policy, Ad=7, Action=Male, Reward=1
Iteration 186: Policy=random_policy, Ad=67, Action=Male, Reward=1
Iteration 187: Policy=random_policy, Ad=1, Action=Female, Reward=0
Iteration 188: Policy=random_policy, Ad=66, Action=Female, Reward=1
Iteration 189: Policy=random_policy, Ad=5, Action=Male, Reward=1
Iteration 190: Policy=random_policy, Ad=4, Action=Male, Reward=0
Iteration 191: Policy=random_policy, Ad=1, Action=Male, Reward=0
Iteration 192: Policy=random_policy, Ad=2, Action=Female, Reward=1

Iteration 193: Policy=random_policy, Ad=34, Action=Female, Reward=1
Iteration 194: Policy=random_policy, Ad=48, Action=Male, Reward=0
Iteration 195: Policy=random_policy, Ad=1, Action=Female, Reward=1
Iteration 196: Policy=random_policy, Ad=26, Action=Female, Reward=1
Iteration 197: Policy=random_policy, Ad=57, Action=Male, Reward=1
Iteration 198: Policy=random_policy, Ad=49, Action=Male, Reward=0
Iteration 199: Policy=random_policy, Ad=74, Action=Female, Reward=1
Iteration 200: Policy=random_policy, Ad=92, Action=Female, Reward=1
Iteration 201: Policy=random_policy, Ad=83, Action=Male, Reward=0
Iteration 202: Policy=random_policy, Ad=25, Action=Female, Reward=1
Iteration 203: Policy=random_policy, Ad=31, Action=Male, Reward=1
Iteration 204: Policy=random_policy, Ad=38, Action=Male, Reward=0
Iteration 205: Policy=random_policy, Ad=18, Action=Female, Reward=1
Iteration 206: Policy=random_policy, Ad=84, Action=Male, Reward=1
Iteration 207: Policy=random_policy, Ad=48, Action=Male, Reward=0
Iteration 208: Policy=random_policy, Ad=67, Action=Female, Reward=0
Iteration 209: Policy=random_policy, Ad=47, Action=Female, Reward=1
Iteration 210: Policy=random_policy, Ad=40, Action=Female, Reward=0
Iteration 211: Policy=random_policy, Ad=94, Action=Female, Reward=1
Iteration 212: Policy=random_policy, Ad=93, Action=Male, Reward=1
Iteration 213: Policy=random_policy, Ad=37, Action=Female, Reward=1
Iteration 214: Policy=random_policy, Ad=13, Action=Male, Reward=1
Iteration 215: Policy=random_policy, Ad=44, Action=Male, Reward=1
Iteration 216: Policy=random_policy, Ad=66, Action=Female, Reward=1
Iteration 217: Policy=random_policy, Ad=91, Action=Female, Reward=1
Iteration 218: Policy=random_policy, Ad=16, Action=Female, Reward=1
Iteration 219: Policy=random_policy, Ad=65, Action=Male, Reward=1
Iteration 220: Policy=random_policy, Ad=73, Action=Male, Reward=0
Iteration 221: Policy=random_policy, Ad=99, Action=Male, Reward=1
Iteration 222: Policy=random_policy, Ad=7, Action=Male, Reward=1
Iteration 223: Policy=random_policy, Ad=41, Action=Male, Reward=1
Iteration 224: Policy=random_policy, Ad=32, Action=Male, Reward=1
Iteration 225: Policy=random_policy, Ad=27, Action=Female, Reward=1
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Iteration 232: Policy=random_policy, Ad=31, Action=Female, Reward=1
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Iteration 235: Policy=random_policy, Ad=78, Action=Female, Reward=0
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Iteration 566: Policy=random_policy, Ad=57, Action=Female, Reward=1
Iteration 567: Policy=random_policy, Ad=62, Action=Male, Reward=0
Iteration 568: Policy=random_policy, Ad=17, Action=Female, Reward=0
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Iteration 570: Policy=random_policy, Ad=42, Action=Female, Reward=1
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Iteration 892: Policy=random_policy, Ad=73, Action=Male, Reward=1
Iteration 893: Policy=random_policy, Ad=30, Action=Female, Reward=0
Iteration 894: Policy=random_policy, Ad=28, Action=Female, Reward=1
Iteration 895: Policy=random_policy, Ad=35, Action=Male, Reward=1
Iteration 896: Policy=random_policy, Ad=39, Action=Male, Reward=0

Iteration 897: Policy=random_policy, Ad=59, Action=Female, Reward=1
Iteration 898: Policy=random_policy, Ad=37, Action=Female, Reward=1
Iteration 899: Policy=random_policy, Ad=92, Action=Male, Reward=1
Iteration 900: Policy=random_policy, Ad=40, Action=Male, Reward=0
Iteration 901: Policy=random_policy, Ad=37, Action=Female, Reward=0
Iteration 902: Policy=random_policy, Ad=98, Action=Male, Reward=0
Iteration 903: Policy=random_policy, Ad=16, Action=Male, Reward=1
Iteration 904: Policy=random_policy, Ad=55, Action=Female, Reward=1
Iteration 905: Policy=random_policy, Ad=89, Action=Female, Reward=0
Iteration 906: Policy=random_policy, Ad=55, Action=Female, Reward=0
Iteration 907: Policy=random_policy, Ad=72, Action=Male, Reward=0
Iteration 908: Policy=random_policy, Ad=33, Action=Male, Reward=1
Iteration 909: Policy=random_policy, Ad=27, Action=Male, Reward=1
Iteration 910: Policy=random_policy, Ad=66, Action=Male, Reward=1
Iteration 911: Policy=random_policy, Ad=45, Action=Female, Reward=0
Iteration 912: Policy=random_policy, Ad=61, Action=Female, Reward=0
Iteration 913: Policy=random_policy, Ad=54, Action=Male, Reward=1
Iteration 914: Policy=random_policy, Ad=37, Action=Female, Reward=1
Iteration 915: Policy=random_policy, Ad=46, Action=Male, Reward=1
Iteration 916: Policy=random_policy, Ad=52, Action=Male, Reward=0
Iteration 917: Policy=random_policy, Ad=69, Action=Female, Reward=1
Iteration 918: Policy=random_policy, Ad=93, Action=Male, Reward=0
Iteration 919: Policy=random_policy, Ad=96, Action=Female, Reward=0
Iteration 920: Policy=random_policy, Ad=25, Action=Male, Reward=0
Iteration 921: Policy=random_policy, Ad=78, Action=Female, Reward=0
Iteration 922: Policy=random_policy, Ad=29, Action=Male, Reward=1
Iteration 923: Policy=random_policy, Ad=19, Action=Female, Reward=1
Iteration 924: Policy=random_policy, Ad=71, Action=Male, Reward=1
Iteration 925: Policy=random_policy, Ad=62, Action=Male, Reward=1
Iteration 926: Policy=random_policy, Ad=62, Action=Female, Reward=1
Iteration 927: Policy=random_policy, Ad=50, Action=Male, Reward=0
Iteration 928: Policy=random_policy, Ad=44, Action=Male, Reward=1
Iteration 929: Policy=random_policy, Ad=88, Action=Female, Reward=1
Iteration 930: Policy=random_policy, Ad=71, Action=Female, Reward=1
Iteration 931: Policy=random_policy, Ad=68, Action=Male, Reward=1
Iteration 932: Policy=random_policy, Ad=37, Action=Female, Reward=0
Iteration 933: Policy=random_policy, Ad=28, Action=Male, Reward=1
Iteration 934: Policy=random_policy, Ad=40, Action=Female, Reward=1
Iteration 935: Policy=random_policy, Ad=76, Action=Male, Reward=1
Iteration 936: Policy=random_policy, Ad=81, Action=Female, Reward=0
Iteration 937: Policy=random_policy, Ad=10, Action=Female, Reward=0
Iteration 938: Policy=random_policy, Ad=11, Action=Female, Reward=0
Iteration 939: Policy=random_policy, Ad=99, Action=Male, Reward=1
Iteration 940: Policy=random_policy, Ad=7, Action=Male, Reward=0
Iteration 941: Policy=random_policy, Ad=14, Action=Male, Reward=1
Iteration 942: Policy=random_policy, Ad=87, Action=Male, Reward=1
Iteration 943: Policy=random_policy, Ad=47, Action=Female, Reward=1
Iteration 944: Policy=random_policy, Ad=36, Action=Male, Reward=1
Iteration 945: Policy=random_policy, Ad=81, Action=Female, Reward=0
Iteration 946: Policy=random_policy, Ad=20, Action=Male, Reward=1
Iteration 947: Policy=random_policy, Ad=75, Action=Female, Reward=1
Iteration 948: Policy=random_policy, Ad=31, Action=Male, Reward=1
Iteration 949: Policy=random_policy, Ad=52, Action=Male, Reward=0
Iteration 950: Policy=random_policy, Ad=31, Action=Male, Reward=1
Iteration 951: Policy=random_policy, Ad=51, Action=Female, Reward=0
Iteration 952: Policy=random_policy, Ad=47, Action=Female, Reward=1
Iteration 953: Policy=random_policy, Ad=85, Action=Female, Reward=0
Iteration 954: Policy=random_policy, Ad=24, Action=Female, Reward=0
Iteration 955: Policy=random_policy, Ad=85, Action=Male, Reward=0
Iteration 956: Policy=random_policy, Ad=62, Action=Male, Reward=1
Iteration 957: Policy=random_policy, Ad=81, Action=Female, Reward=1
Iteration 958: Policy=random_policy, Ad=54, Action=Male, Reward=0
Iteration 959: Policy=random_policy, Ad=74, Action=Female, Reward=1
Iteration 960: Policy=random_policy, Ad=93, Action=Female, Reward=0

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Iteration 961: Policy=random_policy, Ad=43, Action=Female, Reward=1
Iteration 962: Policy=random_policy, Ad=14, Action=Male, Reward=0
Iteration 963: Policy=random_policy, Ad=28, Action=Female, Reward=1
Iteration 964: Policy=random_policy, Ad=17, Action=Female, Reward=0
Iteration 965: Policy=random_policy, Ad=96, Action=Male, Reward=1
Iteration 966: Policy=random_policy, Ad=43, Action=Male, Reward=1
Iteration 967: Policy=random_policy, Ad=99, Action=Female, Reward=1
Iteration 968: Policy=random_policy, Ad=52, Action=Male, Reward=1
Iteration 969: Policy=random_policy, Ad=88, Action=Female, Reward=1
Iteration 970: Policy=random_policy, Ad=48, Action=Male, Reward=1
Iteration 971: Policy=random_policy, Ad=42, Action=Female, Reward=1
Iteration 972: Policy=random_policy, Ad=69, Action=Female, Reward=1
Iteration 973: Policy=random_policy, Ad=13, Action=Male, Reward=1
Iteration 974: Policy=random_policy, Ad=77, Action=Female, Reward=0
Iteration 975: Policy=random_policy, Ad=50, Action=Male, Reward=1
Iteration 976: Policy=random_policy, Ad=60, Action=Female, Reward=1
Iteration 977: Policy=random_policy, Ad=11, Action=Female, Reward=1
Iteration 978: Policy=random_policy, Ad=9, Action=Male, Reward=1
Iteration 979: Policy=random_policy, Ad=51, Action=Male, Reward=1
Iteration 980: Policy=random_policy, Ad=41, Action=Female, Reward=1
Iteration 981: Policy=random_policy, Ad=29, Action=Female, Reward=1
Iteration 982: Policy=random_policy, Ad=24, Action=Male, Reward=1
Iteration 983: Policy=random_policy, Ad=90, Action=Male, Reward=1
Iteration 984: Policy=random_policy, Ad=49, Action=Male, Reward=1
Iteration 985: Policy=random_policy, Ad=29, Action=Female, Reward=1
Iteration 986: Policy=random_policy, Ad=12, Action=Male, Reward=0
Iteration 987: Policy=random_policy, Ad=80, Action=Male, Reward=1
Iteration 988: Policy=random_policy, Ad=59, Action=Female, Reward=1
Iteration 989: Policy=random_policy, Ad=2, Action=Female, Reward=0
Iteration 990: Policy=random_policy, Ad=74, Action=Female, Reward=0
Iteration 991: Policy=random_policy, Ad=92, Action=Male, Reward=0
Iteration 992: Policy=random_policy, Ad=8, Action=Male, Reward=0
Iteration 993: Policy=random_policy, Ad=57, Action=Female, Reward=1
Iteration 994: Policy=random_policy, Ad=26, Action=Male, Reward=1
Iteration 995: Policy=random_policy, Ad=56, Action=Male, Reward=0
Iteration 996: Policy=random_policy, Ad=7, Action=Male, Reward=1
Iteration 997: Policy=random_policy, Ad=21, Action=Female, Reward=0
Iteration 998: Policy=random_policy, Ad=57, Action=Female, Reward=1
Iteration 999: Policy=random_policy, Ad=69, Action=Female, Reward=0
Iteration 1000: Policy=random_policy, Ad=34, Action=Female, Reward=1

```

Using Greedy Policy (0.5M)

Print all the iterations with random policy selected for the given Ad. (Mandatory)

```

In [ ]: # run the environment with an agent that is guided by a greedy policy
#-----write your code below this line-----
# Initialize variables for Greedy policy
def greedy_policy(env, ad_index):
    if env.action_counts[ad_index] == 0:
        return random.choice(['Male', 'Female'])
    else:
        return 'Male' if env.get_reward(ad_index, 'Male') >= env.get_reward(ad_index, 'Female')

env.iterations = 0 # Reset iterations for clear comparison
env.action_counts = np.zeros(len(df))
greedy_avg_rewards = env.run(greedy_policy, num_iterations)

```

Iteration 1: Policy=greedy_policy, Ad=44, Action=Female, Reward=1
Iteration 2: Policy=greedy_policy, Ad=88, Action=Female, Reward=0
Iteration 3: Policy=greedy_policy, Ad=91, Action=Male, Reward=0
Iteration 4: Policy=greedy_policy, Ad=2, Action=Male, Reward=0
Iteration 5: Policy=greedy_policy, Ad=6, Action=Male, Reward=1
Iteration 6: Policy=greedy_policy, Ad=81, Action=Male, Reward=1
Iteration 7: Policy=greedy_policy, Ad=17, Action=Female, Reward=1
Iteration 8: Policy=greedy_policy, Ad=92, Action=Female, Reward=0
Iteration 9: Policy=greedy_policy, Ad=80, Action=Female, Reward=0
Iteration 10: Policy=greedy_policy, Ad=99, Action=Female, Reward=1
Iteration 11: Policy=greedy_policy, Ad=70, Action=Female, Reward=0
Iteration 12: Policy=greedy_policy, Ad=64, Action=Male, Reward=1
Iteration 13: Policy=greedy_policy, Ad=8, Action=Male, Reward=0
Iteration 14: Policy=greedy_policy, Ad=89, Action=Female, Reward=0
Iteration 15: Policy=greedy_policy, Ad=43, Action=Female, Reward=0
Iteration 16: Policy=greedy_policy, Ad=54, Action=Female, Reward=1
Iteration 17: Policy=greedy_policy, Ad=49, Action=Male, Reward=0
Iteration 18: Policy=greedy_policy, Ad=60, Action=Female, Reward=0
Iteration 19: Policy=greedy_policy, Ad=8, Action=Male, Reward=1
Iteration 20: Policy=greedy_policy, Ad=41, Action=Female, Reward=0
Iteration 21: Policy=greedy_policy, Ad=80, Action=Male, Reward=1
Iteration 22: Policy=greedy_policy, Ad=21, Action=Male, Reward=1
Iteration 23: Policy=greedy_policy, Ad=69, Action=Female, Reward=0
Iteration 24: Policy=greedy_policy, Ad=32, Action=Male, Reward=1
Iteration 25: Policy=greedy_policy, Ad=46, Action=Female, Reward=1
Iteration 26: Policy=greedy_policy, Ad=1, Action=Female, Reward=1
Iteration 27: Policy=greedy_policy, Ad=56, Action=Male, Reward=1
Iteration 28: Policy=greedy_policy, Ad=90, Action=Female, Reward=1
Iteration 29: Policy=greedy_policy, Ad=99, Action=Male, Reward=0
Iteration 30: Policy=greedy_policy, Ad=52, Action=Female, Reward=0
Iteration 31: Policy=greedy_policy, Ad=79, Action=Female, Reward=0
Iteration 32: Policy=greedy_policy, Ad=74, Action=Male, Reward=1
Iteration 33: Policy=greedy_policy, Ad=74, Action=Male, Reward=1
Iteration 34: Policy=greedy_policy, Ad=66, Action=Male, Reward=1
Iteration 35: Policy=greedy_policy, Ad=23, Action=Male, Reward=1
Iteration 36: Policy=greedy_policy, Ad=58, Action=Male, Reward=1
Iteration 37: Policy=greedy_policy, Ad=36, Action=Female, Reward=1
Iteration 38: Policy=greedy_policy, Ad=82, Action=Female, Reward=0
Iteration 39: Policy=greedy_policy, Ad=45, Action=Male, Reward=1
Iteration 40: Policy=greedy_policy, Ad=10, Action=Male, Reward=1
Iteration 41: Policy=greedy_policy, Ad=6, Action=Male, Reward=1
Iteration 42: Policy=greedy_policy, Ad=19, Action=Male, Reward=1
Iteration 43: Policy=greedy_policy, Ad=21, Action=Male, Reward=1
Iteration 44: Policy=greedy_policy, Ad=62, Action=Male, Reward=1
Iteration 45: Policy=greedy_policy, Ad=89, Action=Male, Reward=1
Iteration 46: Policy=greedy_policy, Ad=18, Action=Male, Reward=1
Iteration 47: Policy=greedy_policy, Ad=11, Action=Male, Reward=0
Iteration 48: Policy=greedy_policy, Ad=54, Action=Female, Reward=1
Iteration 49: Policy=greedy_policy, Ad=79, Action=Male, Reward=1
Iteration 50: Policy=greedy_policy, Ad=50, Action=Male, Reward=1
Iteration 51: Policy=greedy_policy, Ad=2, Action=Male, Reward=1
Iteration 52: Policy=greedy_policy, Ad=87, Action=Female, Reward=1
Iteration 53: Policy=greedy_policy, Ad=31, Action=Male, Reward=1
Iteration 54: Policy=greedy_policy, Ad=86, Action=Female, Reward=0
Iteration 55: Policy=greedy_policy, Ad=45, Action=Male, Reward=1
Iteration 56: Policy=greedy_policy, Ad=7, Action=Male, Reward=1
Iteration 57: Policy=greedy_policy, Ad=82, Action=Male, Reward=1
Iteration 58: Policy=greedy_policy, Ad=83, Action=Female, Reward=1
Iteration 59: Policy=greedy_policy, Ad=92, Action=Female, Reward=0
Iteration 60: Policy=greedy_policy, Ad=32, Action=Male, Reward=1
Iteration 61: Policy=greedy_policy, Ad=44, Action=Male, Reward=1
Iteration 62: Policy=greedy_policy, Ad=64, Action=Male, Reward=1
Iteration 63: Policy=greedy_policy, Ad=91, Action=Male, Reward=1
Iteration 64: Policy=greedy_policy, Ad=50, Action=Male, Reward=0

Iteration 65: Policy=greedy_policy, Ad=16, Action=Male, Reward=1
Iteration 66: Policy=greedy_policy, Ad=33, Action=Female, Reward=1
Iteration 67: Policy=greedy_policy, Ad=12, Action=Male, Reward=1
Iteration 68: Policy=greedy_policy, Ad=37, Action=Male, Reward=1
Iteration 69: Policy=greedy_policy, Ad=42, Action=Male, Reward=1
Iteration 70: Policy=greedy_policy, Ad=93, Action=Female, Reward=0
Iteration 71: Policy=greedy_policy, Ad=99, Action=Female, Reward=0
Iteration 72: Policy=greedy_policy, Ad=52, Action=Female, Reward=1
Iteration 73: Policy=greedy_policy, Ad=47, Action=Female, Reward=1
Iteration 74: Policy=greedy_policy, Ad=70, Action=Male, Reward=0
Iteration 75: Policy=greedy_policy, Ad=96, Action=Female, Reward=1
Iteration 76: Policy=greedy_policy, Ad=38, Action=Female, Reward=1
Iteration 77: Policy=greedy_policy, Ad=47, Action=Female, Reward=1
Iteration 78: Policy=greedy_policy, Ad=74, Action=Male, Reward=0
Iteration 79: Policy=greedy_policy, Ad=95, Action=Male, Reward=1
Iteration 80: Policy=greedy_policy, Ad=23, Action=Male, Reward=1
Iteration 81: Policy=greedy_policy, Ad=31, Action=Male, Reward=0
Iteration 82: Policy=greedy_policy, Ad=64, Action=Male, Reward=0
Iteration 83: Policy=greedy_policy, Ad=76, Action=Female, Reward=1
Iteration 84: Policy=greedy_policy, Ad=24, Action=Male, Reward=1
Iteration 85: Policy=greedy_policy, Ad=47, Action=Female, Reward=1
Iteration 86: Policy=greedy_policy, Ad=9, Action=Male, Reward=1
Iteration 87: Policy=greedy_policy, Ad=6, Action=Male, Reward=0
Iteration 88: Policy=greedy_policy, Ad=20, Action=Female, Reward=1
Iteration 89: Policy=greedy_policy, Ad=53, Action=Male, Reward=1
Iteration 90: Policy=greedy_policy, Ad=89, Action=Male, Reward=1
Iteration 91: Policy=greedy_policy, Ad=90, Action=Male, Reward=0
Iteration 92: Policy=greedy_policy, Ad=12, Action=Male, Reward=1
Iteration 93: Policy=greedy_policy, Ad=72, Action=Male, Reward=0
Iteration 94: Policy=greedy_policy, Ad=22, Action=Female, Reward=0
Iteration 95: Policy=greedy_policy, Ad=18, Action=Male, Reward=1
Iteration 96: Policy=greedy_policy, Ad=37, Action=Male, Reward=1
Iteration 97: Policy=greedy_policy, Ad=73, Action=Male, Reward=0
Iteration 98: Policy=greedy_policy, Ad=84, Action=Male, Reward=1
Iteration 99: Policy=greedy_policy, Ad=0, Action=Female, Reward=1
Iteration 100: Policy=greedy_policy, Ad=16, Action=Male, Reward=1
Iteration 101: Policy=greedy_policy, Ad=93, Action=Female, Reward=1
Iteration 102: Policy=greedy_policy, Ad=48, Action=Male, Reward=1
Iteration 103: Policy=greedy_policy, Ad=98, Action=Female, Reward=1
Iteration 104: Policy=greedy_policy, Ad=22, Action=Female, Reward=0
Iteration 105: Policy=greedy_policy, Ad=26, Action=Female, Reward=0
Iteration 106: Policy=greedy_policy, Ad=57, Action=Female, Reward=1
Iteration 107: Policy=greedy_policy, Ad=72, Action=Male, Reward=1
Iteration 108: Policy=greedy_policy, Ad=63, Action=Female, Reward=0
Iteration 109: Policy=greedy_policy, Ad=86, Action=Male, Reward=0
Iteration 110: Policy=greedy_policy, Ad=33, Action=Male, Reward=0
Iteration 111: Policy=greedy_policy, Ad=20, Action=Male, Reward=1
Iteration 112: Policy=greedy_policy, Ad=42, Action=Female, Reward=1
Iteration 113: Policy=greedy_policy, Ad=8, Action=Male, Reward=1
Iteration 114: Policy=greedy_policy, Ad=17, Action=Male, Reward=0
Iteration 115: Policy=greedy_policy, Ad=11, Action=Male, Reward=1
Iteration 116: Policy=greedy_policy, Ad=40, Action=Female, Reward=1
Iteration 117: Policy=greedy_policy, Ad=28, Action=Male, Reward=1
Iteration 118: Policy=greedy_policy, Ad=83, Action=Male, Reward=1
Iteration 119: Policy=greedy_policy, Ad=57, Action=Male, Reward=0
Iteration 120: Policy=greedy_policy, Ad=0, Action=Male, Reward=1
Iteration 121: Policy=greedy_policy, Ad=92, Action=Male, Reward=1
Iteration 122: Policy=greedy_policy, Ad=45, Action=Male, Reward=1
Iteration 123: Policy=greedy_policy, Ad=14, Action=Female, Reward=0
Iteration 124: Policy=greedy_policy, Ad=35, Action=Female, Reward=0
Iteration 125: Policy=greedy_policy, Ad=42, Action=Male, Reward=1
Iteration 126: Policy=greedy_policy, Ad=44, Action=Male, Reward=1
Iteration 127: Policy=greedy_policy, Ad=25, Action=Male, Reward=1
Iteration 128: Policy=greedy_policy, Ad=34, Action=Female, Reward=1

Iteration 129: Policy=greedy_policy, Ad=74, Action=Male, Reward=1
Iteration 130: Policy=greedy_policy, Ad=40, Action=Female, Reward=1
Iteration 131: Policy=greedy_policy, Ad=41, Action=Male, Reward=1
Iteration 132: Policy=greedy_policy, Ad=7, Action=Male, Reward=1
Iteration 133: Policy=greedy_policy, Ad=6, Action=Male, Reward=0
Iteration 134: Policy=greedy_policy, Ad=32, Action=Male, Reward=1
Iteration 135: Policy=greedy_policy, Ad=24, Action=Male, Reward=1
Iteration 136: Policy=greedy_policy, Ad=84, Action=Male, Reward=1
Iteration 137: Policy=greedy_policy, Ad=43, Action=Female, Reward=1
Iteration 138: Policy=greedy_policy, Ad=42, Action=Male, Reward=1
Iteration 139: Policy=greedy_policy, Ad=91, Action=Male, Reward=0
Iteration 140: Policy=greedy_policy, Ad=70, Action=Male, Reward=0
Iteration 141: Policy=greedy_policy, Ad=36, Action=Male, Reward=1
Iteration 142: Policy=greedy_policy, Ad=49, Action=Male, Reward=1
Iteration 143: Policy=greedy_policy, Ad=92, Action=Male, Reward=1
Iteration 144: Policy=greedy_policy, Ad=47, Action=Male, Reward=0
Iteration 145: Policy=greedy_policy, Ad=89, Action=Male, Reward=1
Iteration 146: Policy=greedy_policy, Ad=90, Action=Male, Reward=0
Iteration 147: Policy=greedy_policy, Ad=82, Action=Male, Reward=1
Iteration 148: Policy=greedy_policy, Ad=93, Action=Female, Reward=1
Iteration 149: Policy=greedy_policy, Ad=86, Action=Male, Reward=1
Iteration 150: Policy=greedy_policy, Ad=91, Action=Male, Reward=1
Iteration 151: Policy=greedy_policy, Ad=92, Action=Male, Reward=1
Iteration 152: Policy=greedy_policy, Ad=92, Action=Male, Reward=1
Iteration 153: Policy=greedy_policy, Ad=72, Action=Male, Reward=1
Iteration 154: Policy=greedy_policy, Ad=30, Action=Male, Reward=0
Iteration 155: Policy=greedy_policy, Ad=93, Action=Male, Reward=1
Iteration 156: Policy=greedy_policy, Ad=72, Action=Male, Reward=1
Iteration 157: Policy=greedy_policy, Ad=25, Action=Female, Reward=0
Iteration 158: Policy=greedy_policy, Ad=34, Action=Male, Reward=1
Iteration 159: Policy=greedy_policy, Ad=21, Action=Male, Reward=1
Iteration 160: Policy=greedy_policy, Ad=93, Action=Female, Reward=0
Iteration 161: Policy=greedy_policy, Ad=45, Action=Male, Reward=1
Iteration 162: Policy=greedy_policy, Ad=76, Action=Female, Reward=1
Iteration 163: Policy=greedy_policy, Ad=71, Action=Male, Reward=1
Iteration 164: Policy=greedy_policy, Ad=62, Action=Female, Reward=1
Iteration 165: Policy=greedy_policy, Ad=19, Action=Male, Reward=0
Iteration 166: Policy=greedy_policy, Ad=99, Action=Male, Reward=0
Iteration 167: Policy=greedy_policy, Ad=14, Action=Male, Reward=1
Iteration 168: Policy=greedy_policy, Ad=77, Action=Female, Reward=1
Iteration 169: Policy=greedy_policy, Ad=84, Action=Male, Reward=1
Iteration 170: Policy=greedy_policy, Ad=85, Action=Female, Reward=0
Iteration 171: Policy=greedy_policy, Ad=78, Action=Male, Reward=1
Iteration 172: Policy=greedy_policy, Ad=15, Action=Male, Reward=1
Iteration 173: Policy=greedy_policy, Ad=16, Action=Male, Reward=0
Iteration 174: Policy=greedy_policy, Ad=9, Action=Male, Reward=1
Iteration 175: Policy=greedy_policy, Ad=40, Action=Female, Reward=0
Iteration 176: Policy=greedy_policy, Ad=29, Action=Female, Reward=1
Iteration 177: Policy=greedy_policy, Ad=97, Action=Female, Reward=1
Iteration 178: Policy=greedy_policy, Ad=10, Action=Male, Reward=0
Iteration 179: Policy=greedy_policy, Ad=58, Action=Male, Reward=0
Iteration 180: Policy=greedy_policy, Ad=71, Action=Male, Reward=1
Iteration 181: Policy=greedy_policy, Ad=37, Action=Male, Reward=1
Iteration 182: Policy=greedy_policy, Ad=50, Action=Male, Reward=1
Iteration 183: Policy=greedy_policy, Ad=75, Action=Male, Reward=0
Iteration 184: Policy=greedy_policy, Ad=22, Action=Male, Reward=0
Iteration 185: Policy=greedy_policy, Ad=93, Action=Male, Reward=1
Iteration 186: Policy=greedy_policy, Ad=38, Action=Male, Reward=0
Iteration 187: Policy=greedy_policy, Ad=17, Action=Male, Reward=1
Iteration 188: Policy=greedy_policy, Ad=61, Action=Male, Reward=1
Iteration 189: Policy=greedy_policy, Ad=44, Action=Male, Reward=1
Iteration 190: Policy=greedy_policy, Ad=5, Action=Male, Reward=1
Iteration 191: Policy=greedy_policy, Ad=36, Action=Male, Reward=1
Iteration 192: Policy=greedy_policy, Ad=11, Action=Male, Reward=0

Iteration 193: Policy=greedy_policy, Ad=39, Action=Female, Reward=0
Iteration 194: Policy=greedy_policy, Ad=14, Action=Male, Reward=0
Iteration 195: Policy=greedy_policy, Ad=28, Action=Male, Reward=0
Iteration 196: Policy=greedy_policy, Ad=75, Action=Male, Reward=1
Iteration 197: Policy=greedy_policy, Ad=70, Action=Female, Reward=0
Iteration 198: Policy=greedy_policy, Ad=13, Action=Male, Reward=1
Iteration 199: Policy=greedy_policy, Ad=79, Action=Male, Reward=1
Iteration 200: Policy=greedy_policy, Ad=78, Action=Male, Reward=0
Iteration 201: Policy=greedy_policy, Ad=82, Action=Male, Reward=1
Iteration 202: Policy=greedy_policy, Ad=40, Action=Male, Reward=1
Iteration 203: Policy=greedy_policy, Ad=5, Action=Male, Reward=0
Iteration 204: Policy=greedy_policy, Ad=52, Action=Male, Reward=1
Iteration 205: Policy=greedy_policy, Ad=21, Action=Male, Reward=1
Iteration 206: Policy=greedy_policy, Ad=31, Action=Male, Reward=1
Iteration 207: Policy=greedy_policy, Ad=42, Action=Female, Reward=0
Iteration 208: Policy=greedy_policy, Ad=22, Action=Male, Reward=1
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Iteration 849: Policy=greedy_policy, Ad=43, Action=Male, Reward=1
Iteration 850: Policy=greedy_policy, Ad=92, Action=Male, Reward=1
Iteration 851: Policy=greedy_policy, Ad=34, Action=Male, Reward=1
Iteration 852: Policy=greedy_policy, Ad=27, Action=Male, Reward=0
Iteration 853: Policy=greedy_policy, Ad=99, Action=Female, Reward=1
Iteration 854: Policy=greedy_policy, Ad=35, Action=Male, Reward=0
Iteration 855: Policy=greedy_policy, Ad=56, Action=Male, Reward=1
Iteration 856: Policy=greedy_policy, Ad=43, Action=Male, Reward=1
Iteration 857: Policy=greedy_policy, Ad=45, Action=Male, Reward=1
Iteration 858: Policy=greedy_policy, Ad=47, Action=Male, Reward=0
Iteration 859: Policy=greedy_policy, Ad=36, Action=Male, Reward=0
Iteration 860: Policy=greedy_policy, Ad=77, Action=Female, Reward=1
Iteration 861: Policy=greedy_policy, Ad=98, Action=Male, Reward=0
Iteration 862: Policy=greedy_policy, Ad=39, Action=Female, Reward=1
Iteration 863: Policy=greedy_policy, Ad=5, Action=Male, Reward=1
Iteration 864: Policy=greedy_policy, Ad=27, Action=Male, Reward=1
Iteration 865: Policy=greedy_policy, Ad=15, Action=Male, Reward=1
Iteration 866: Policy=greedy_policy, Ad=16, Action=Male, Reward=1
Iteration 867: Policy=greedy_policy, Ad=76, Action=Male, Reward=0
Iteration 868: Policy=greedy_policy, Ad=75, Action=Male, Reward=1
Iteration 869: Policy=greedy_policy, Ad=73, Action=Male, Reward=1
Iteration 870: Policy=greedy_policy, Ad=80, Action=Male, Reward=0
Iteration 871: Policy=greedy_policy, Ad=23, Action=Female, Reward=1
Iteration 872: Policy=greedy_policy, Ad=36, Action=Male, Reward=1
Iteration 873: Policy=greedy_policy, Ad=53, Action=Male, Reward=1
Iteration 874: Policy=greedy_policy, Ad=83, Action=Male, Reward=1
Iteration 875: Policy=greedy_policy, Ad=76, Action=Male, Reward=1
Iteration 876: Policy=greedy_policy, Ad=1, Action=Male, Reward=0
Iteration 877: Policy=greedy_policy, Ad=86, Action=Male, Reward=1
Iteration 878: Policy=greedy_policy, Ad=50, Action=Male, Reward=1
Iteration 879: Policy=greedy_policy, Ad=97, Action=Male, Reward=0
Iteration 880: Policy=greedy_policy, Ad=0, Action=Male, Reward=1
Iteration 881: Policy=greedy_policy, Ad=72, Action=Male, Reward=1
Iteration 882: Policy=greedy_policy, Ad=41, Action=Male, Reward=1
Iteration 883: Policy=greedy_policy, Ad=38, Action=Male, Reward=0
Iteration 884: Policy=greedy_policy, Ad=3, Action=Female, Reward=1
Iteration 885: Policy=greedy_policy, Ad=12, Action=Male, Reward=1
Iteration 886: Policy=greedy_policy, Ad=88, Action=Male, Reward=1
Iteration 887: Policy=greedy_policy, Ad=1, Action=Male, Reward=1
Iteration 888: Policy=greedy_policy, Ad=95, Action=Male, Reward=0
Iteration 889: Policy=greedy_policy, Ad=73, Action=Female, Reward=0
Iteration 890: Policy=greedy_policy, Ad=12, Action=Male, Reward=1
Iteration 891: Policy=greedy_policy, Ad=31, Action=Male, Reward=0
Iteration 892: Policy=greedy_policy, Ad=35, Action=Male, Reward=1
Iteration 893: Policy=greedy_policy, Ad=21, Action=Male, Reward=1
Iteration 894: Policy=greedy_policy, Ad=35, Action=Male, Reward=1
Iteration 895: Policy=greedy_policy, Ad=48, Action=Female, Reward=0
Iteration 896: Policy=greedy_policy, Ad=17, Action=Male, Reward=1

Iteration 897: Policy=greedy_policy, Ad=36, Action=Female, Reward=0
Iteration 898: Policy=greedy_policy, Ad=76, Action=Male, Reward=1
Iteration 899: Policy=greedy_policy, Ad=73, Action=Male, Reward=0
Iteration 900: Policy=greedy_policy, Ad=5, Action=Male, Reward=1
Iteration 901: Policy=greedy_policy, Ad=37, Action=Male, Reward=1
Iteration 902: Policy=greedy_policy, Ad=92, Action=Male, Reward=1
Iteration 903: Policy=greedy_policy, Ad=60, Action=Male, Reward=0
Iteration 904: Policy=greedy_policy, Ad=83, Action=Female, Reward=1
Iteration 905: Policy=greedy_policy, Ad=94, Action=Female, Reward=1
Iteration 906: Policy=greedy_policy, Ad=33, Action=Male, Reward=0
Iteration 907: Policy=greedy_policy, Ad=45, Action=Male, Reward=0
Iteration 908: Policy=greedy_policy, Ad=47, Action=Male, Reward=1
Iteration 909: Policy=greedy_policy, Ad=4, Action=Male, Reward=1
Iteration 910: Policy=greedy_policy, Ad=2, Action=Male, Reward=0
Iteration 911: Policy=greedy_policy, Ad=70, Action=Male, Reward=1
Iteration 912: Policy=greedy_policy, Ad=14, Action=Male, Reward=1
Iteration 913: Policy=greedy_policy, Ad=39, Action=Female, Reward=1
Iteration 914: Policy=greedy_policy, Ad=78, Action=Male, Reward=1
Iteration 915: Policy=greedy_policy, Ad=10, Action=Male, Reward=1
Iteration 916: Policy=greedy_policy, Ad=62, Action=Male, Reward=0
Iteration 917: Policy=greedy_policy, Ad=56, Action=Male, Reward=0
Iteration 918: Policy=greedy_policy, Ad=60, Action=Male, Reward=1
Iteration 919: Policy=greedy_policy, Ad=14, Action=Male, Reward=1
Iteration 920: Policy=greedy_policy, Ad=36, Action=Female, Reward=1
Iteration 921: Policy=greedy_policy, Ad=82, Action=Male, Reward=0
Iteration 922: Policy=greedy_policy, Ad=49, Action=Male, Reward=1
Iteration 923: Policy=greedy_policy, Ad=85, Action=Male, Reward=1
Iteration 924: Policy=greedy_policy, Ad=61, Action=Male, Reward=0
Iteration 925: Policy=greedy_policy, Ad=78, Action=Male, Reward=1
Iteration 926: Policy=greedy_policy, Ad=94, Action=Male, Reward=1
Iteration 927: Policy=greedy_policy, Ad=52, Action=Male, Reward=0
Iteration 928: Policy=greedy_policy, Ad=83, Action=Male, Reward=1
Iteration 929: Policy=greedy_policy, Ad=45, Action=Male, Reward=0
Iteration 930: Policy=greedy_policy, Ad=9, Action=Female, Reward=1
Iteration 931: Policy=greedy_policy, Ad=59, Action=Male, Reward=0
Iteration 932: Policy=greedy_policy, Ad=38, Action=Male, Reward=1
Iteration 933: Policy=greedy_policy, Ad=20, Action=Male, Reward=1
Iteration 934: Policy=greedy_policy, Ad=13, Action=Male, Reward=1
Iteration 935: Policy=greedy_policy, Ad=22, Action=Female, Reward=1
Iteration 936: Policy=greedy_policy, Ad=75, Action=Male, Reward=1
Iteration 937: Policy=greedy_policy, Ad=67, Action=Male, Reward=0
Iteration 938: Policy=greedy_policy, Ad=60, Action=Male, Reward=0
Iteration 939: Policy=greedy_policy, Ad=25, Action=Male, Reward=0
Iteration 940: Policy=greedy_policy, Ad=10, Action=Male, Reward=1
Iteration 941: Policy=greedy_policy, Ad=51, Action=Male, Reward=1
Iteration 942: Policy=greedy_policy, Ad=14, Action=Female, Reward=1
Iteration 943: Policy=greedy_policy, Ad=37, Action=Male, Reward=1
Iteration 944: Policy=greedy_policy, Ad=98, Action=Male, Reward=1
Iteration 945: Policy=greedy_policy, Ad=24, Action=Male, Reward=0
Iteration 946: Policy=greedy_policy, Ad=77, Action=Male, Reward=1
Iteration 947: Policy=greedy_policy, Ad=20, Action=Male, Reward=1
Iteration 948: Policy=greedy_policy, Ad=7, Action=Female, Reward=1
Iteration 949: Policy=greedy_policy, Ad=51, Action=Male, Reward=1
Iteration 950: Policy=greedy_policy, Ad=3, Action=Male, Reward=0
Iteration 951: Policy=greedy_policy, Ad=62, Action=Female, Reward=1
Iteration 952: Policy=greedy_policy, Ad=15, Action=Male, Reward=0
Iteration 953: Policy=greedy_policy, Ad=43, Action=Male, Reward=0
Iteration 954: Policy=greedy_policy, Ad=9, Action=Male, Reward=1
Iteration 955: Policy=greedy_policy, Ad=31, Action=Male, Reward=0
Iteration 956: Policy=greedy_policy, Ad=19, Action=Female, Reward=0
Iteration 957: Policy=greedy_policy, Ad=95, Action=Male, Reward=0
Iteration 958: Policy=greedy_policy, Ad=0, Action=Male, Reward=0
Iteration 959: Policy=greedy_policy, Ad=31, Action=Male, Reward=0
Iteration 960: Policy=greedy_policy, Ad=64, Action=Male, Reward=1

```

Iteration 961: Policy=greedy_policy, Ad=15, Action=Male, Reward=0
Iteration 962: Policy=greedy_policy, Ad=55, Action=Male, Reward=1
Iteration 963: Policy=greedy_policy, Ad=14, Action=Male, Reward=1
Iteration 964: Policy=greedy_policy, Ad=89, Action=Male, Reward=1
Iteration 965: Policy=greedy_policy, Ad=61, Action=Male, Reward=1
Iteration 966: Policy=greedy_policy, Ad=70, Action=Female, Reward=0
Iteration 967: Policy=greedy_policy, Ad=28, Action=Male, Reward=0
Iteration 968: Policy=greedy_policy, Ad=41, Action=Male, Reward=1
Iteration 969: Policy=greedy_policy, Ad=24, Action=Male, Reward=1
Iteration 970: Policy=greedy_policy, Ad=81, Action=Female, Reward=0
Iteration 971: Policy=greedy_policy, Ad=42, Action=Male, Reward=1
Iteration 972: Policy=greedy_policy, Ad=52, Action=Male, Reward=1
Iteration 973: Policy=greedy_policy, Ad=2, Action=Male, Reward=1
Iteration 974: Policy=greedy_policy, Ad=40, Action=Male, Reward=1
Iteration 975: Policy=greedy_policy, Ad=83, Action=Male, Reward=0
Iteration 976: Policy=greedy_policy, Ad=87, Action=Male, Reward=1
Iteration 977: Policy=greedy_policy, Ad=99, Action=Male, Reward=1
Iteration 978: Policy=greedy_policy, Ad=38, Action=Female, Reward=1
Iteration 979: Policy=greedy_policy, Ad=42, Action=Male, Reward=1
Iteration 980: Policy=greedy_policy, Ad=65, Action=Male, Reward=0
Iteration 981: Policy=greedy_policy, Ad=14, Action=Male, Reward=0
Iteration 982: Policy=greedy_policy, Ad=33, Action=Male, Reward=1
Iteration 983: Policy=greedy_policy, Ad=75, Action=Male, Reward=0
Iteration 984: Policy=greedy_policy, Ad=60, Action=Male, Reward=1
Iteration 985: Policy=greedy_policy, Ad=21, Action=Male, Reward=1
Iteration 986: Policy=greedy_policy, Ad=11, Action=Male, Reward=1
Iteration 987: Policy=greedy_policy, Ad=1, Action=Male, Reward=0
Iteration 988: Policy=greedy_policy, Ad=2, Action=Male, Reward=1
Iteration 989: Policy=greedy_policy, Ad=59, Action=Male, Reward=1
Iteration 990: Policy=greedy_policy, Ad=97, Action=Male, Reward=0
Iteration 991: Policy=greedy_policy, Ad=74, Action=Male, Reward=1
Iteration 992: Policy=greedy_policy, Ad=28, Action=Male, Reward=0
Iteration 993: Policy=greedy_policy, Ad=71, Action=Male, Reward=1
Iteration 994: Policy=greedy_policy, Ad=77, Action=Female, Reward=1
Iteration 995: Policy=greedy_policy, Ad=57, Action=Male, Reward=0
Iteration 996: Policy=greedy_policy, Ad=95, Action=Male, Reward=0
Iteration 997: Policy=greedy_policy, Ad=3, Action=Female, Reward=0
Iteration 998: Policy=greedy_policy, Ad=2, Action=Male, Reward=1
Iteration 999: Policy=greedy_policy, Ad=21, Action=Male, Reward=0
Iteration 1000: Policy=greedy_policy, Ad=74, Action=Male, Reward=1

```

Using Epsilon-Greedy Policy (0.5M)

Print all the iterations with random policy selected for the given Ad. (Mandatory)

```

In [ ]: # run the environment with an agent that is guided by a epsilon-greedy policy
#-----write your code below this line-----
import numpy as np
# Initialize variables for Epsilon-Greedy policy
def epsilon_greedy_policy(env, ad_index, epsilon=0.1):
    if random.random() < epsilon:
        return random.choice(['Male', 'Female'])
    else:
        return 'Male' if env.get_reward(ad_index, 'Male') >= env.get_reward(ad_index, 'Female')

env.iterations = 0 # Reset iterations for clear comparison
env.action_counts = np.zeros(len(df))
epsilon_greedy_avg_rewards = env.run(epsilon_greedy_policy, num_iterations)

```

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

```

Iteration 961: Policy=epsilon_greedy_policy, Ad=2, Action=Male, Reward=1
Iteration 962: Policy=epsilon_greedy_policy, Ad=30, Action=Male, Reward=1
Iteration 963: Policy=epsilon_greedy_policy, Ad=61, Action=Male, Reward=1
Iteration 964: Policy=epsilon_greedy_policy, Ad=19, Action=Male, Reward=1
Iteration 965: Policy=epsilon_greedy_policy, Ad=63, Action=Male, Reward=1
Iteration 966: Policy=epsilon_greedy_policy, Ad=87, Action=Female, Reward=1
Iteration 967: Policy=epsilon_greedy_policy, Ad=84, Action=Female, Reward=0
Iteration 968: Policy=epsilon_greedy_policy, Ad=74, Action=Male, Reward=0
Iteration 969: Policy=epsilon_greedy_policy, Ad=48, Action=Male, Reward=1
Iteration 970: Policy=epsilon_greedy_policy, Ad=78, Action=Female, Reward=0
Iteration 971: Policy=epsilon_greedy_policy, Ad=90, Action=Male, Reward=1
Iteration 972: Policy=epsilon_greedy_policy, Ad=27, Action=Male, Reward=0
Iteration 973: Policy=epsilon_greedy_policy, Ad=14, Action=Female, Reward=0
Iteration 974: Policy=epsilon_greedy_policy, Ad=6, Action=Female, Reward=0
Iteration 975: Policy=epsilon_greedy_policy, Ad=43, Action=Male, Reward=0
Iteration 976: Policy=epsilon_greedy_policy, Ad=70, Action=Male, Reward=1
Iteration 977: Policy=epsilon_greedy_policy, Ad=95, Action=Male, Reward=1
Iteration 978: Policy=epsilon_greedy_policy, Ad=23, Action=Male, Reward=1
Iteration 979: Policy=epsilon_greedy_policy, Ad=82, Action=Male, Reward=0
Iteration 980: Policy=epsilon_greedy_policy, Ad=48, Action=Male, Reward=1
Iteration 981: Policy=epsilon_greedy_policy, Ad=80, Action=Male, Reward=1
Iteration 982: Policy=epsilon_greedy_policy, Ad=0, Action=Male, Reward=1
Iteration 983: Policy=epsilon_greedy_policy, Ad=57, Action=Male, Reward=1
Iteration 984: Policy=epsilon_greedy_policy, Ad=87, Action=Male, Reward=1
Iteration 985: Policy=epsilon_greedy_policy, Ad=56, Action=Male, Reward=0
Iteration 986: Policy=epsilon_greedy_policy, Ad=73, Action=Male, Reward=1
Iteration 987: Policy=epsilon_greedy_policy, Ad=46, Action=Male, Reward=1
Iteration 988: Policy=epsilon_greedy_policy, Ad=10, Action=Female, Reward=1
Iteration 989: Policy=epsilon_greedy_policy, Ad=95, Action=Male, Reward=0
Iteration 990: Policy=epsilon_greedy_policy, Ad=8, Action=Male, Reward=0
Iteration 991: Policy=epsilon_greedy_policy, Ad=3, Action=Male, Reward=0
Iteration 992: Policy=epsilon_greedy_policy, Ad=22, Action=Male, Reward=1
Iteration 993: Policy=epsilon_greedy_policy, Ad=8, Action=Male, Reward=1
Iteration 994: Policy=epsilon_greedy_policy, Ad=53, Action=Female, Reward=1
Iteration 995: Policy=epsilon_greedy_policy, Ad=97, Action=Male, Reward=1
Iteration 996: Policy=epsilon_greedy_policy, Ad=10, Action=Male, Reward=0
Iteration 997: Policy=epsilon_greedy_policy, Ad=61, Action=Male, Reward=1
Iteration 998: Policy=epsilon_greedy_policy, Ad=19, Action=Male, Reward=0
Iteration 999: Policy=epsilon_greedy_policy, Ad=74, Action=Male, Reward=1
Iteration 1000: Policy=epsilon_greedy_policy, Ad=44, Action=Female, Reward=0

```

Using UCB (0.5M)

Print all the iterations with random policy selected for the given Ad. (Mandatory)

```

In [ ]: # run the environment with an agent that is guided by a UCB
#-----write your code below this line-----
# The ucb_policy function selects the action ('Male' or 'Female') with the
# highest Upper Confidence Bound (UCB) value
# for a given ad index, balancing exploration and exploitation.
def ucb_policy(env, ad_index):
    ucb_values = []
    total_counts = np.sum(env.action_counts)
    for action in ['Male', 'Female']:
        if env.action_counts[ad_index] == 0:
            ucb_value = float('inf')
        else:
            exploit_term = env.get_reward(ad_index, action) / env.action_counts[ad_index]
            explore_term = np.sqrt((2 * np.log(total_counts)) / env.action_counts[ad_index])
            ucb_value = exploit_term + explore_term
        ucb_values.append(ucb_value)
    return 'Male' if ucb_values[0] >= ucb_values[1] else 'Female'

```

```
env.iterations = 0 # Reset iterations for clear comparison
env.action_counts = np.zeros(len(df))
ucb_avg_rewards = env.run(ucb_policy, num_iterations)
```

Iteration 1: Policy=ucb_policy, Ad=86, Action=Male, Reward=1
Iteration 2: Policy=ucb_policy, Ad=61, Action=Male, Reward=1
Iteration 3: Policy=ucb_policy, Ad=73, Action=Male, Reward=1
Iteration 4: Policy=ucb_policy, Ad=33, Action=Male, Reward=0
Iteration 5: Policy=ucb_policy, Ad=77, Action=Male, Reward=1
Iteration 6: Policy=ucb_policy, Ad=49, Action=Male, Reward=1
Iteration 7: Policy=ucb_policy, Ad=61, Action=Male, Reward=1
Iteration 8: Policy=ucb_policy, Ad=62, Action=Male, Reward=0
Iteration 9: Policy=ucb_policy, Ad=72, Action=Male, Reward=0
Iteration 10: Policy=ucb_policy, Ad=24, Action=Male, Reward=0
Iteration 11: Policy=ucb_policy, Ad=47, Action=Male, Reward=1
Iteration 12: Policy=ucb_policy, Ad=72, Action=Female, Reward=1
Iteration 13: Policy=ucb_policy, Ad=27, Action=Male, Reward=1
Iteration 14: Policy=ucb_policy, Ad=18, Action=Male, Reward=0
Iteration 15: Policy=ucb_policy, Ad=22, Action=Male, Reward=1
Iteration 16: Policy=ucb_policy, Ad=50, Action=Male, Reward=1
Iteration 17: Policy=ucb_policy, Ad=94, Action=Male, Reward=1
Iteration 18: Policy=ucb_policy, Ad=85, Action=Male, Reward=1
Iteration 19: Policy=ucb_policy, Ad=19, Action=Male, Reward=0
Iteration 20: Policy=ucb_policy, Ad=63, Action=Male, Reward=0
Iteration 21: Policy=ucb_policy, Ad=54, Action=Male, Reward=1
Iteration 22: Policy=ucb_policy, Ad=42, Action=Male, Reward=1
Iteration 23: Policy=ucb_policy, Ad=90, Action=Male, Reward=1
Iteration 24: Policy=ucb_policy, Ad=91, Action=Male, Reward=1
Iteration 25: Policy=ucb_policy, Ad=71, Action=Male, Reward=1
Iteration 26: Policy=ucb_policy, Ad=93, Action=Male, Reward=0
Iteration 27: Policy=ucb_policy, Ad=75, Action=Male, Reward=0
Iteration 28: Policy=ucb_policy, Ad=2, Action=Male, Reward=1
Iteration 29: Policy=ucb_policy, Ad=7, Action=Male, Reward=1
Iteration 30: Policy=ucb_policy, Ad=85, Action=Male, Reward=1
Iteration 31: Policy=ucb_policy, Ad=31, Action=Male, Reward=0
Iteration 32: Policy=ucb_policy, Ad=46, Action=Male, Reward=0
Iteration 33: Policy=ucb_policy, Ad=79, Action=Male, Reward=1
Iteration 34: Policy=ucb_policy, Ad=46, Action=Male, Reward=1
Iteration 35: Policy=ucb_policy, Ad=24, Action=Male, Reward=1
Iteration 36: Policy=ucb_policy, Ad=47, Action=Female, Reward=0
Iteration 37: Policy=ucb_policy, Ad=90, Action=Male, Reward=1
Iteration 38: Policy=ucb_policy, Ad=56, Action=Male, Reward=1
Iteration 39: Policy=ucb_policy, Ad=15, Action=Male, Reward=1
Iteration 40: Policy=ucb_policy, Ad=79, Action=Male, Reward=1
Iteration 41: Policy=ucb_policy, Ad=67, Action=Male, Reward=1
Iteration 42: Policy=ucb_policy, Ad=85, Action=Male, Reward=1
Iteration 43: Policy=ucb_policy, Ad=20, Action=Male, Reward=0
Iteration 44: Policy=ucb_policy, Ad=92, Action=Male, Reward=1
Iteration 45: Policy=ucb_policy, Ad=67, Action=Male, Reward=1
Iteration 46: Policy=ucb_policy, Ad=83, Action=Male, Reward=0
Iteration 47: Policy=ucb_policy, Ad=79, Action=Male, Reward=1
Iteration 48: Policy=ucb_policy, Ad=82, Action=Male, Reward=1
Iteration 49: Policy=ucb_policy, Ad=25, Action=Male, Reward=1
Iteration 50: Policy=ucb_policy, Ad=93, Action=Male, Reward=1
Iteration 51: Policy=ucb_policy, Ad=88, Action=Male, Reward=1
Iteration 52: Policy=ucb_policy, Ad=23, Action=Male, Reward=1
Iteration 53: Policy=ucb_policy, Ad=38, Action=Male, Reward=1
Iteration 54: Policy=ucb_policy, Ad=90, Action=Female, Reward=1
Iteration 55: Policy=ucb_policy, Ad=95, Action=Male, Reward=1
Iteration 56: Policy=ucb_policy, Ad=33, Action=Male, Reward=0
Iteration 57: Policy=ucb_policy, Ad=23, Action=Male, Reward=0
Iteration 58: Policy=ucb_policy, Ad=44, Action=Male, Reward=1
Iteration 59: Policy=ucb_policy, Ad=2, Action=Female, Reward=0
Iteration 60: Policy=ucb_policy, Ad=61, Action=Male, Reward=1
Iteration 61: Policy=ucb_policy, Ad=0, Action=Male, Reward=1
Iteration 62: Policy=ucb_policy, Ad=49, Action=Male, Reward=0
Iteration 63: Policy=ucb_policy, Ad=16, Action=Male, Reward=0
Iteration 64: Policy=ucb_policy, Ad=37, Action=Male, Reward=1

Iteration 65: Policy=ucb_policy, Ad=72, Action=Male, Reward=0
Iteration 66: Policy=ucb_policy, Ad=79, Action=Female, Reward=0
Iteration 67: Policy=ucb_policy, Ad=76, Action=Male, Reward=1
Iteration 68: Policy=ucb_policy, Ad=70, Action=Male, Reward=0
Iteration 69: Policy=ucb_policy, Ad=70, Action=Male, Reward=0
Iteration 70: Policy=ucb_policy, Ad=57, Action=Male, Reward=1
Iteration 71: Policy=ucb_policy, Ad=56, Action=Male, Reward=1
Iteration 72: Policy=ucb_policy, Ad=79, Action=Male, Reward=1
Iteration 73: Policy=ucb_policy, Ad=13, Action=Male, Reward=1
Iteration 74: Policy=ucb_policy, Ad=60, Action=Male, Reward=1
Iteration 75: Policy=ucb_policy, Ad=49, Action=Male, Reward=1
Iteration 76: Policy=ucb_policy, Ad=90, Action=Male, Reward=1
Iteration 77: Policy=ucb_policy, Ad=46, Action=Male, Reward=1
Iteration 78: Policy=ucb_policy, Ad=67, Action=Male, Reward=1
Iteration 79: Policy=ucb_policy, Ad=65, Action=Male, Reward=1
Iteration 80: Policy=ucb_policy, Ad=10, Action=Male, Reward=1
Iteration 81: Policy=ucb_policy, Ad=23, Action=Male, Reward=1
Iteration 82: Policy=ucb_policy, Ad=58, Action=Male, Reward=1
Iteration 83: Policy=ucb_policy, Ad=18, Action=Male, Reward=0
Iteration 84: Policy=ucb_policy, Ad=36, Action=Male, Reward=1
Iteration 85: Policy=ucb_policy, Ad=51, Action=Male, Reward=1
Iteration 86: Policy=ucb_policy, Ad=20, Action=Female, Reward=1
Iteration 87: Policy=ucb_policy, Ad=39, Action=Male, Reward=1
Iteration 88: Policy=ucb_policy, Ad=35, Action=Male, Reward=0
Iteration 89: Policy=ucb_policy, Ad=5, Action=Male, Reward=0
Iteration 90: Policy=ucb_policy, Ad=12, Action=Male, Reward=1
Iteration 91: Policy=ucb_policy, Ad=87, Action=Male, Reward=1
Iteration 92: Policy=ucb_policy, Ad=13, Action=Male, Reward=0
Iteration 93: Policy=ucb_policy, Ad=83, Action=Male, Reward=1
Iteration 94: Policy=ucb_policy, Ad=82, Action=Male, Reward=0
Iteration 95: Policy=ucb_policy, Ad=41, Action=Male, Reward=1
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Iteration 746: Policy=ucb_policy, Ad=57, Action=Male, Reward=1
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Iteration 778: Policy=ucb_policy, Ad=41, Action=Female, Reward=0
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Iteration 814: Policy=ucb_policy, Ad=12, Action=Male, Reward=1
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Iteration 823: Policy=ucb_policy, Ad=61, Action=Female, Reward=0
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Iteration 826: Policy=ucb_policy, Ad=40, Action=Male, Reward=1
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Iteration 829: Policy=ucb_policy, Ad=68, Action=Male, Reward=1
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Iteration 869: Policy=ucb_policy, Ad=80, Action=Male, Reward=1
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Iteration 889: Policy=ucb_policy, Ad=29, Action=Female, Reward=0
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Iteration 908: Policy=ucb_policy, Ad=32, Action=Male, Reward=0
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Iteration 912: Policy=ucb_policy, Ad=57, Action=Male, Reward=0
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Iteration 914: Policy=ucb_policy, Ad=86, Action=Male, Reward=0
Iteration 915: Policy=ucb_policy, Ad=42, Action=Male, Reward=0
Iteration 916: Policy=ucb_policy, Ad=20, Action=Male, Reward=0
Iteration 917: Policy=ucb_policy, Ad=84, Action=Male, Reward=0
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Iteration 919: Policy=ucb_policy, Ad=23, Action=Male, Reward=1
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Iteration 930: Policy=ucb_policy, Ad=82, Action=Male, Reward=1
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Iteration 947: Policy=ucb_policy, Ad=57, Action=Male, Reward=0
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Iteration 951: Policy=ucb_policy, Ad=96, Action=Male, Reward=1
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Iteration 954: Policy=ucb_policy, Ad=41, Action=Male, Reward=0
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Iteration 956: Policy=ucb_policy, Ad=54, Action=Male, Reward=1
Iteration 957: Policy=ucb_policy, Ad=41, Action=Male, Reward=1
Iteration 958: Policy=ucb_policy, Ad=16, Action=Male, Reward=1
Iteration 959: Policy=ucb_policy, Ad=44, Action=Male, Reward=1
Iteration 960: Policy=ucb_policy, Ad=21, Action=Female, Reward=1

```

Iteration 961: Policy=ucb_policy, Ad=73, Action=Male, Reward=1
Iteration 962: Policy=ucb_policy, Ad=19, Action=Male, Reward=0
Iteration 963: Policy=ucb_policy, Ad=44, Action=Male, Reward=1
Iteration 964: Policy=ucb_policy, Ad=47, Action=Male, Reward=0
Iteration 965: Policy=ucb_policy, Ad=35, Action=Male, Reward=1
Iteration 966: Policy=ucb_policy, Ad=70, Action=Male, Reward=0
Iteration 967: Policy=ucb_policy, Ad=49, Action=Female, Reward=0
Iteration 968: Policy=ucb_policy, Ad=91, Action=Male, Reward=0
Iteration 969: Policy=ucb_policy, Ad=43, Action=Male, Reward=0
Iteration 970: Policy=ucb_policy, Ad=64, Action=Male, Reward=0
Iteration 971: Policy=ucb_policy, Ad=82, Action=Female, Reward=1
Iteration 972: Policy=ucb_policy, Ad=70, Action=Male, Reward=0
Iteration 973: Policy=ucb_policy, Ad=52, Action=Female, Reward=1
Iteration 974: Policy=ucb_policy, Ad=6, Action=Male, Reward=0
Iteration 975: Policy=ucb_policy, Ad=66, Action=Male, Reward=0
Iteration 976: Policy=ucb_policy, Ad=90, Action=Male, Reward=1
Iteration 977: Policy=ucb_policy, Ad=97, Action=Female, Reward=1
Iteration 978: Policy=ucb_policy, Ad=18, Action=Male, Reward=1
Iteration 979: Policy=ucb_policy, Ad=5, Action=Male, Reward=1
Iteration 980: Policy=ucb_policy, Ad=12, Action=Male, Reward=1
Iteration 981: Policy=ucb_policy, Ad=22, Action=Male, Reward=1
Iteration 982: Policy=ucb_policy, Ad=42, Action=Male, Reward=0
Iteration 983: Policy=ucb_policy, Ad=71, Action=Male, Reward=0
Iteration 984: Policy=ucb_policy, Ad=38, Action=Female, Reward=0
Iteration 985: Policy=ucb_policy, Ad=2, Action=Male, Reward=0
Iteration 986: Policy=ucb_policy, Ad=93, Action=Male, Reward=1
Iteration 987: Policy=ucb_policy, Ad=6, Action=Male, Reward=0
Iteration 988: Policy=ucb_policy, Ad=83, Action=Male, Reward=1
Iteration 989: Policy=ucb_policy, Ad=12, Action=Male, Reward=1
Iteration 990: Policy=ucb_policy, Ad=26, Action=Female, Reward=1
Iteration 991: Policy=ucb_policy, Ad=73, Action=Female, Reward=0
Iteration 992: Policy=ucb_policy, Ad=57, Action=Female, Reward=1
Iteration 993: Policy=ucb_policy, Ad=83, Action=Male, Reward=1
Iteration 994: Policy=ucb_policy, Ad=46, Action=Male, Reward=0
Iteration 995: Policy=ucb_policy, Ad=10, Action=Male, Reward=1
Iteration 996: Policy=ucb_policy, Ad=10, Action=Male, Reward=1
Iteration 997: Policy=ucb_policy, Ad=53, Action=Male, Reward=1
Iteration 998: Policy=ucb_policy, Ad=83, Action=Male, Reward=1
Iteration 999: Policy=ucb_policy, Ad=73, Action=Male, Reward=0
Iteration 1000: Policy=ucb_policy, Ad=82, Action=Male, Reward=1

```

Plot CTR distribution for all the appraoches as a spearate graph (0.5M)

```

In [ ]: #-----write your code below this line-----
import matplotlib.pyplot as plt

# Plotting CTR distributions in one graph (line plot for average rewards)
plt.figure(figsize=(10, 6))

# Random Policy
plt.plot(range(1, num_iterations + 1), random_rewards, label='Random Policy')

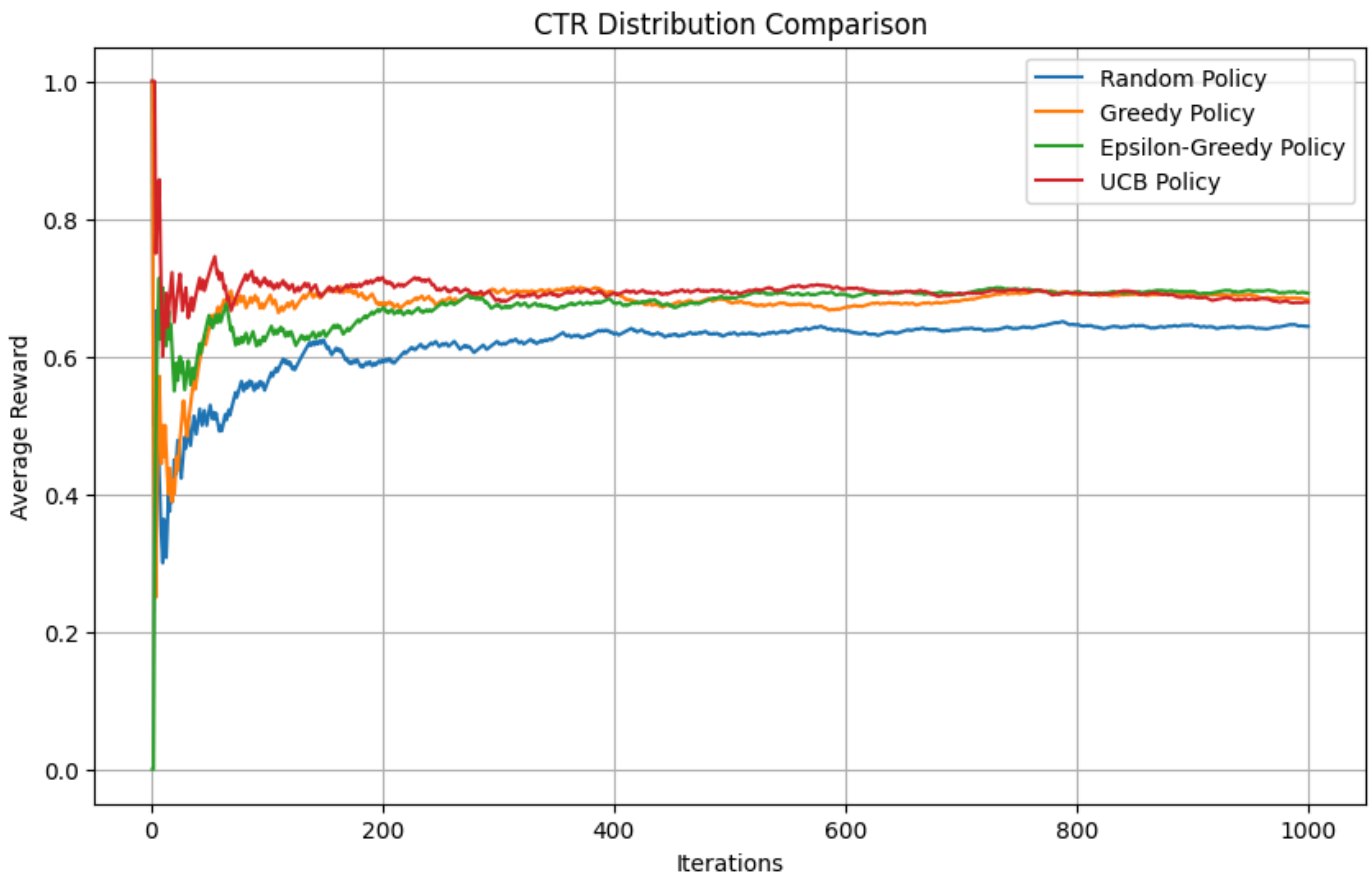
# Greedy Policy
plt.plot(range(1, num_iterations + 1), greedy_avg_rewards, label='Greedy Policy')

# Epsilon-Greedy Policy
plt.plot(range(1, num_iterations + 1), epsilon_greedy_avg_rewards, label='Epsilon-Greedy Policy')

# UCB Policy
plt.plot(range(1, num_iterations + 1), ucb_avg_rewards, label='UCB Policy')

```

```
plt.title('CTR Distribution Comparison')
plt.xlabel('Iterations')
plt.ylabel('Average Reward')
plt.legend()
plt.grid(True)
plt.show()
```



Changing Exploration Percentage (1M)

- How does changing the exploration percentage (EXPLORE_PERCENTAGE) affect the performance of the algorithm? Test with different values (e.g. 0.15 and 0.2) and discuss the results.

```
In [ ]: #Implement with any MAB algorithm
#Try with different EXPLORE_PERCENTAGE
#Different value of alpha

# Test with different exploration percentages and alpha values
explore_percentages = [0.1, 0.15, 0.2]
alphas = [0.1, 0.2, 0.3]

for explore_percentage in explore_percentages:
    for alpha in alphas:
        print(f"\nExploration Percentage: {explore_percentage}, Alpha: {alpha}")
        env.alpha = alpha
        avg_rewards = env.run(epsilon_greedy_policy, num_iterations=1000, epsilon=explore_percent
        print("Average Rewards:", avg_rewards[-10:]) # Print last 10 average rewards
```

Streaming output truncated to the last 5000 lines.

Iteration 8014: Policy=epsilon_greedy_policy, Ad=35, Action=Male, Reward=0
Iteration 8015: Policy=epsilon_greedy_policy, Ad=12, Action=Male, Reward=1
Iteration 8016: Policy=epsilon_greedy_policy, Ad=5, Action=Male, Reward=1
Iteration 8017: Policy=epsilon_greedy_policy, Ad=31, Action=Male, Reward=0
Iteration 8018: Policy=epsilon_greedy_policy, Ad=15, Action=Male, Reward=1
Iteration 8019: Policy=epsilon_greedy_policy, Ad=65, Action=Male, Reward=1
Iteration 8020: Policy=epsilon_greedy_policy, Ad=7, Action=Female, Reward=0
Iteration 8021: Policy=epsilon_greedy_policy, Ad=27, Action=Male, Reward=1
Iteration 8022: Policy=epsilon_greedy_policy, Ad=85, Action=Male, Reward=1
Iteration 8023: Policy=epsilon_greedy_policy, Ad=34, Action=Male, Reward=1
Iteration 8024: Policy=epsilon_greedy_policy, Ad=83, Action=Female, Reward=1
Iteration 8025: Policy=epsilon_greedy_policy, Ad=79, Action=Male, Reward=1
Iteration 8026: Policy=epsilon_greedy_policy, Ad=8, Action=Male, Reward=1
Iteration 8027: Policy=epsilon_greedy_policy, Ad=96, Action=Male, Reward=0
Iteration 8028: Policy=epsilon_greedy_policy, Ad=97, Action=Male, Reward=1
Iteration 8029: Policy=epsilon_greedy_policy, Ad=75, Action=Male, Reward=1
Iteration 8030: Policy=epsilon_greedy_policy, Ad=81, Action=Male, Reward=0
Iteration 8031: Policy=epsilon_greedy_policy, Ad=5, Action=Male, Reward=1
Iteration 8032: Policy=epsilon_greedy_policy, Ad=16, Action=Female, Reward=0
Iteration 8033: Policy=epsilon_greedy_policy, Ad=12, Action=Male, Reward=1
Iteration 8034: Policy=epsilon_greedy_policy, Ad=82, Action=Male, Reward=1
Iteration 8035: Policy=epsilon_greedy_policy, Ad=65, Action=Male, Reward=1
Iteration 8036: Policy=epsilon_greedy_policy, Ad=61, Action=Female, Reward=1
Iteration 8037: Policy=epsilon_greedy_policy, Ad=82, Action=Male, Reward=1
Iteration 8038: Policy=epsilon_greedy_policy, Ad=26, Action=Male, Reward=1
Iteration 8039: Policy=epsilon_greedy_policy, Ad=77, Action=Male, Reward=1
Iteration 8040: Policy=epsilon_greedy_policy, Ad=34, Action=Male, Reward=1
Iteration 8041: Policy=epsilon_greedy_policy, Ad=83, Action=Male, Reward=1
Iteration 8042: Policy=epsilon_greedy_policy, Ad=22, Action=Male, Reward=1
Iteration 8043: Policy=epsilon_greedy_policy, Ad=55, Action=Female, Reward=1
Iteration 8044: Policy=epsilon_greedy_policy, Ad=47, Action=Male, Reward=1
Iteration 8045: Policy=epsilon_greedy_policy, Ad=50, Action=Male, Reward=0
Iteration 8046: Policy=epsilon_greedy_policy, Ad=60, Action=Male, Reward=1
Iteration 8047: Policy=epsilon_greedy_policy, Ad=35, Action=Male, Reward=1
Iteration 8048: Policy=epsilon_greedy_policy, Ad=90, Action=Male, Reward=0
Iteration 8049: Policy=epsilon_greedy_policy, Ad=43, Action=Male, Reward=0
Iteration 8050: Policy=epsilon_greedy_policy, Ad=57, Action=Male, Reward=0
Iteration 8051: Policy=epsilon_greedy_policy, Ad=56, Action=Male, Reward=1
Iteration 8052: Policy=epsilon_greedy_policy, Ad=16, Action=Male, Reward=1
Iteration 8053: Policy=epsilon_greedy_policy, Ad=7, Action=Male, Reward=1
Iteration 8054: Policy=epsilon_greedy_policy, Ad=35, Action=Male, Reward=1
Iteration 8055: Policy=epsilon_greedy_policy, Ad=49, Action=Male, Reward=1
Iteration 8056: Policy=epsilon_greedy_policy, Ad=0, Action=Male, Reward=0
Iteration 8057: Policy=epsilon_greedy_policy, Ad=25, Action=Male, Reward=1
Iteration 8058: Policy=epsilon_greedy_policy, Ad=77, Action=Female, Reward=1
Iteration 8059: Policy=epsilon_greedy_policy, Ad=76, Action=Male, Reward=1
Iteration 8060: Policy=epsilon_greedy_policy, Ad=54, Action=Female, Reward=1
Iteration 8061: Policy=epsilon_greedy_policy, Ad=94, Action=Male, Reward=0
Iteration 8062: Policy=epsilon_greedy_policy, Ad=84, Action=Male, Reward=0
Iteration 8063: Policy=epsilon_greedy_policy, Ad=8, Action=Male, Reward=1
Iteration 8064: Policy=epsilon_greedy_policy, Ad=58, Action=Male, Reward=1
Iteration 8065: Policy=epsilon_greedy_policy, Ad=26, Action=Male, Reward=1
Iteration 8066: Policy=epsilon_greedy_policy, Ad=16, Action=Female, Reward=0
Iteration 8067: Policy=epsilon_greedy_policy, Ad=45, Action=Male, Reward=1
Iteration 8068: Policy=epsilon_greedy_policy, Ad=33, Action=Male, Reward=0
Iteration 8069: Policy=epsilon_greedy_policy, Ad=52, Action=Male, Reward=1
Iteration 8070: Policy=epsilon_greedy_policy, Ad=46, Action=Male, Reward=1
Iteration 8071: Policy=epsilon_greedy_policy, Ad=17, Action=Male, Reward=0
Iteration 8072: Policy=epsilon_greedy_policy, Ad=82, Action=Male, Reward=0
Iteration 8073: Policy=epsilon_greedy_policy, Ad=85, Action=Male, Reward=1
Iteration 8074: Policy=epsilon_greedy_policy, Ad=83, Action=Male, Reward=1
Iteration 8075: Policy=epsilon_greedy_policy, Ad=37, Action=Female, Reward=1
Iteration 8076: Policy=epsilon_greedy_policy, Ad=4, Action=Male, Reward=1

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Iteration 8973: Policy=epsilon_greedy_policy, Ad=37, Action=Male, Reward=1
Iteration 8974: Policy=epsilon_greedy_policy, Ad=54, Action=Male, Reward=0
Iteration 8975: Policy=epsilon_greedy_policy, Ad=6, Action=Male, Reward=1
Iteration 8976: Policy=epsilon_greedy_policy, Ad=12, Action=Male, Reward=1
Iteration 8977: Policy=epsilon_greedy_policy, Ad=86, Action=Male, Reward=0
Iteration 8978: Policy=epsilon_greedy_policy, Ad=63, Action=Male, Reward=1
Iteration 8979: Policy=epsilon_greedy_policy, Ad=47, Action=Female, Reward=0
Iteration 8980: Policy=epsilon_greedy_policy, Ad=53, Action=Male, Reward=0
Iteration 8981: Policy=epsilon_greedy_policy, Ad=82, Action=Male, Reward=1
Iteration 8982: Policy=epsilon_greedy_policy, Ad=2, Action=Male, Reward=0
Iteration 8983: Policy=epsilon_greedy_policy, Ad=20, Action=Female, Reward=1
Iteration 8984: Policy=epsilon_greedy_policy, Ad=43, Action=Female, Reward=0
Iteration 8985: Policy=epsilon_greedy_policy, Ad=58, Action=Male, Reward=1
Iteration 8986: Policy=epsilon_greedy_policy, Ad=75, Action=Male, Reward=0
Iteration 8987: Policy=epsilon_greedy_policy, Ad=43, Action=Male, Reward=1
Iteration 8988: Policy=epsilon_greedy_policy, Ad=20, Action=Male, Reward=1
Iteration 8989: Policy=epsilon_greedy_policy, Ad=41, Action=Male, Reward=1
Iteration 8990: Policy=epsilon_greedy_policy, Ad=80, Action=Male, Reward=1
Iteration 8991: Policy=epsilon_greedy_policy, Ad=82, Action=Male, Reward=1
Iteration 8992: Policy=epsilon_greedy_policy, Ad=72, Action=Male, Reward=0
Iteration 8993: Policy=epsilon_greedy_policy, Ad=59, Action=Male, Reward=0
Iteration 8994: Policy=epsilon_greedy_policy, Ad=59, Action=Female, Reward=0
Iteration 8995: Policy=epsilon_greedy_policy, Ad=63, Action=Male, Reward=0
Iteration 8996: Policy=epsilon_greedy_policy, Ad=42, Action=Male, Reward=0
Iteration 8997: Policy=epsilon_greedy_policy, Ad=69, Action=Male, Reward=1
Iteration 8998: Policy=epsilon_greedy_policy, Ad=61, Action=Male, Reward=1
Iteration 8999: Policy=epsilon_greedy_policy, Ad=29, Action=Male, Reward=1
Iteration 9000: Policy=epsilon_greedy_policy, Ad=29, Action=Male, Reward=1
Average Rewards: [0.693239152371342, 0.6925403225806451, 0.6918429003021148, 0.6911468812877264, 0.6904522613065327, 0.6897590361445783, 0.6900702106318957, 0.6903807615230461, 0.6906906906906907, 0.691]

Exploration Percentage: 0.15, Alpha: 0.3

Iteration 9001: Policy=epsilon_greedy_policy, Ad=18, Action=Male, Reward=1
Iteration 9002: Policy=epsilon_greedy_policy, Ad=7, Action=Male, Reward=1
Iteration 9003: Policy=epsilon_greedy_policy, Ad=10, Action=Male, Reward=1
Iteration 9004: Policy=epsilon_greedy_policy, Ad=11, Action=Male, Reward=1
Iteration 9005: Policy=epsilon_greedy_policy, Ad=68, Action=Male, Reward=0
Iteration 9006: Policy=epsilon_greedy_policy, Ad=1, Action=Male, Reward=1
Iteration 9007: Policy=epsilon_greedy_policy, Ad=80, Action=Male, Reward=1
Iteration 9008: Policy=epsilon_greedy_policy, Ad=88, Action=Male, Reward=0
Iteration 9009: Policy=epsilon_greedy_policy, Ad=21, Action=Male, Reward=1
Iteration 9010: Policy=epsilon_greedy_policy, Ad=80, Action=Female, Reward=1
Iteration 9011: Policy=epsilon_greedy_policy, Ad=72, Action=Male, Reward=1
Iteration 9012: Policy=epsilon_greedy_policy, Ad=66, Action=Male, Reward=1
Iteration 9013: Policy=epsilon_greedy_policy, Ad=32, Action=Male, Reward=0
Iteration 9014: Policy=epsilon_greedy_policy, Ad=40, Action=Male, Reward=1
Iteration 9015: Policy=epsilon_greedy_policy, Ad=15, Action=Male, Reward=1
Iteration 9016: Policy=epsilon_greedy_policy, Ad=96, Action=Male, Reward=1
Iteration 9017: Policy=epsilon_greedy_policy, Ad=70, Action=Male, Reward=1
Iteration 9018: Policy=epsilon_greedy_policy, Ad=0, Action=Male, Reward=1
Iteration 9019: Policy=epsilon_greedy_policy, Ad=75, Action=Male, Reward=1
Iteration 9020: Policy=epsilon_greedy_policy, Ad=33, Action=Male, Reward=1
Iteration 9021: Policy=epsilon_greedy_policy, Ad=31, Action=Male, Reward=1
Iteration 9022: Policy=epsilon_greedy_policy, Ad=26, Action=Male, Reward=1
Iteration 9023: Policy=epsilon_greedy_policy, Ad=10, Action=Male, Reward=1
Iteration 9024: Policy=epsilon_greedy_policy, Ad=72, Action=Male, Reward=0
Iteration 9025: Policy=epsilon_greedy_policy, Ad=36, Action=Male, Reward=0
Iteration 9026: Policy=epsilon_greedy_policy, Ad=99, Action=Male, Reward=0
Iteration 9027: Policy=epsilon_greedy_policy, Ad=79, Action=Female, Reward=1
Iteration 9028: Policy=epsilon_greedy_policy, Ad=74, Action=Male, Reward=1
Iteration 9029: Policy=epsilon_greedy_policy, Ad=81, Action=Male, Reward=1
Iteration 9030: Policy=epsilon_greedy_policy, Ad=91, Action=Male, Reward=1
Iteration 9031: Policy=epsilon_greedy_policy, Ad=32, Action=Female, Reward=0

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Iteration 9992: Policy=epsilon_greedy_policy, Ad=6, Action=Male, Reward=1
Iteration 9993: Policy=epsilon_greedy_policy, Ad=56, Action=Male, Reward=0
Iteration 9994: Policy=epsilon_greedy_policy, Ad=15, Action=Male, Reward=0
Iteration 9995: Policy=epsilon_greedy_policy, Ad=31, Action=Male, Reward=1
Iteration 9996: Policy=epsilon_greedy_policy, Ad=34, Action=Male, Reward=1
Iteration 9997: Policy=epsilon_greedy_policy, Ad=6, Action=Male, Reward=0
Iteration 9998: Policy=epsilon_greedy_policy, Ad=33, Action=Male, Reward=1
Iteration 9999: Policy=epsilon_greedy_policy, Ad=24, Action=Male, Reward=1
Iteration 10000: Policy=epsilon_greedy_policy, Ad=29, Action=Male, Reward=1
Average Rewards: [0.7124117053481333, 0.7127016129032258, 0.7119838872104733, 0.711267605633802
9, 0.7115577889447237, 0.7118473895582329, 0.7111334002006018, 0.7114228456913828, 0.71171171171
17117, 0.712]

Exploration Percentage: 0.2, Alpha: 0.1

Iteration 10001: Policy=epsilon_greedy_policy, Ad=13, Action=Female, Reward=0
Iteration 10002: Policy=epsilon_greedy_policy, Ad=7, Action=Male, Reward=1
Iteration 10003: Policy=epsilon_greedy_policy, Ad=24, Action=Female, Reward=1
Iteration 10004: Policy=epsilon_greedy_policy, Ad=63, Action=Male, Reward=1
Iteration 10005: Policy=epsilon_greedy_policy, Ad=34, Action=Male, Reward=0
Iteration 10006: Policy=epsilon_greedy_policy, Ad=79, Action=Male, Reward=0
Iteration 10007: Policy=epsilon_greedy_policy, Ad=78, Action=Male, Reward=1
Iteration 10008: Policy=epsilon_greedy_policy, Ad=32, Action=Female, Reward=1
Iteration 10009: Policy=epsilon_greedy_policy, Ad=51, Action=Male, Reward=1
Iteration 10010: Policy=epsilon_greedy_policy, Ad=97, Action=Female, Reward=0
Iteration 10011: Policy=epsilon_greedy_policy, Ad=16, Action=Male, Reward=0
Iteration 10012: Policy=epsilon_greedy_policy, Ad=27, Action=Male, Reward=1
Iteration 10013: Policy=epsilon_greedy_policy, Ad=21, Action=Male, Reward=1
Iteration 10014: Policy=epsilon_greedy_policy, Ad=49, Action=Female, Reward=0
Iteration 10015: Policy=epsilon_greedy_policy, Ad=66, Action=Female, Reward=0
Iteration 10016: Policy=epsilon_greedy_policy, Ad=6, Action=Male, Reward=1
Iteration 10017: Policy=epsilon_greedy_policy, Ad=93, Action=Male, Reward=1
Iteration 10018: Policy=epsilon_greedy_policy, Ad=72, Action=Male, Reward=1
Iteration 10019: Policy=epsilon_greedy_policy, Ad=64, Action=Male, Reward=0
Iteration 10020: Policy=epsilon_greedy_policy, Ad=79, Action=Male, Reward=1
Iteration 10021: Policy=epsilon_greedy_policy, Ad=52, Action=Male, Reward=0
Iteration 10022: Policy=epsilon_greedy_policy, Ad=26, Action=Female, Reward=0
Iteration 10023: Policy=epsilon_greedy_policy, Ad=2, Action=Male, Reward=1
Iteration 10024: Policy=epsilon_greedy_policy, Ad=89, Action=Male, Reward=0
Iteration 10025: Policy=epsilon_greedy_policy, Ad=87, Action=Male, Reward=1
Iteration 10026: Policy=epsilon_greedy_policy, Ad=12, Action=Male, Reward=0
Iteration 10027: Policy=epsilon_greedy_policy, Ad=11, Action=Female, Reward=1
Iteration 10028: Policy=epsilon_greedy_policy, Ad=28, Action=Male, Reward=0
Iteration 10029: Policy=epsilon_greedy_policy, Ad=45, Action=Male, Reward=1
Iteration 10030: Policy=epsilon_greedy_policy, Ad=6, Action=Male, Reward=1
Iteration 10031: Policy=epsilon_greedy_policy, Ad=73, Action=Male, Reward=0
Iteration 10032: Policy=epsilon_greedy_policy, Ad=48, Action=Male, Reward=0
Iteration 10033: Policy=epsilon_greedy_policy, Ad=28, Action=Male, Reward=1
Iteration 10034: Policy=epsilon_greedy_policy, Ad=52, Action=Female, Reward=1
Iteration 10035: Policy=epsilon_greedy_policy, Ad=66, Action=Male, Reward=1
Iteration 10036: Policy=epsilon_greedy_policy, Ad=80, Action=Male, Reward=1
Iteration 10037: Policy=epsilon_greedy_policy, Ad=84, Action=Female, Reward=0
Iteration 10038: Policy=epsilon_greedy_policy, Ad=65, Action=Male, Reward=0
Iteration 10039: Policy=epsilon_greedy_policy, Ad=53, Action=Male, Reward=1
Iteration 10040: Policy=epsilon_greedy_policy, Ad=55, Action=Male, Reward=1
Iteration 10041: Policy=epsilon_greedy_policy, Ad=56, Action=Male, Reward=1
Iteration 10042: Policy=epsilon_greedy_policy, Ad=95, Action=Male, Reward=1
Iteration 10043: Policy=epsilon_greedy_policy, Ad=23, Action=Female, Reward=1
Iteration 10044: Policy=epsilon_greedy_policy, Ad=9, Action=Male, Reward=1
Iteration 10045: Policy=epsilon_greedy_policy, Ad=70, Action=Male, Reward=1
Iteration 10046: Policy=epsilon_greedy_policy, Ad=95, Action=Male, Reward=1
Iteration 10047: Policy=epsilon_greedy_policy, Ad=49, Action=Male, Reward=1
Iteration 10048: Policy=epsilon_greedy_policy, Ad=11, Action=Male, Reward=1
Iteration 10049: Policy=epsilon_greedy_policy, Ad=24, Action=Male, Reward=0
Iteration 10050: Policy=epsilon_greedy_policy, Ad=35, Action=Female, Reward=1

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Iteration 10947: Policy=epsilon_greedy_policy, Ad=87, Action=Male, Reward=1
Iteration 10948: Policy=epsilon_greedy_policy, Ad=73, Action=Male, Reward=1
Iteration 10949: Policy=epsilon_greedy_policy, Ad=8, Action=Female, Reward=0
Iteration 10950: Policy=epsilon_greedy_policy, Ad=83, Action=Male, Reward=1
Iteration 10951: Policy=epsilon_greedy_policy, Ad=42, Action=Male, Reward=1
Iteration 10952: Policy=epsilon_greedy_policy, Ad=23, Action=Female, Reward=0
Iteration 10953: Policy=epsilon_greedy_policy, Ad=59, Action=Male, Reward=1
Iteration 10954: Policy=epsilon_greedy_policy, Ad=0, Action=Male, Reward=0
Iteration 10955: Policy=epsilon_greedy_policy, Ad=21, Action=Female, Reward=0
Iteration 10956: Policy=epsilon_greedy_policy, Ad=28, Action=Male, Reward=0
Iteration 10957: Policy=epsilon_greedy_policy, Ad=39, Action=Male, Reward=1
Iteration 10958: Policy=epsilon_greedy_policy, Ad=1, Action=Female, Reward=0
Iteration 10959: Policy=epsilon_greedy_policy, Ad=97, Action=Male, Reward=0
Iteration 10960: Policy=epsilon_greedy_policy, Ad=77, Action=Male, Reward=1
Iteration 10961: Policy=epsilon_greedy_policy, Ad=80, Action=Female, Reward=1
Iteration 10962: Policy=epsilon_greedy_policy, Ad=60, Action=Female, Reward=0
Iteration 10963: Policy=epsilon_greedy_policy, Ad=35, Action=Male, Reward=1
Iteration 10964: Policy=epsilon_greedy_policy, Ad=20, Action=Male, Reward=0
Iteration 10965: Policy=epsilon_greedy_policy, Ad=80, Action=Male, Reward=1
Iteration 10966: Policy=epsilon_greedy_policy, Ad=77, Action=Male, Reward=1
Iteration 10967: Policy=epsilon_greedy_policy, Ad=8, Action=Male, Reward=1
Iteration 10968: Policy=epsilon_greedy_policy, Ad=90, Action=Male, Reward=1
Iteration 10969: Policy=epsilon_greedy_policy, Ad=92, Action=Male, Reward=1
Iteration 10970: Policy=epsilon_greedy_policy, Ad=12, Action=Male, Reward=1
Iteration 10971: Policy=epsilon_greedy_policy, Ad=12, Action=Male, Reward=1
Iteration 10972: Policy=epsilon_greedy_policy, Ad=75, Action=Female, Reward=0
Iteration 10973: Policy=epsilon_greedy_policy, Ad=28, Action=Male, Reward=1
Iteration 10974: Policy=epsilon_greedy_policy, Ad=30, Action=Female, Reward=0
Iteration 10975: Policy=epsilon_greedy_policy, Ad=49, Action=Male, Reward=0
Iteration 10976: Policy=epsilon_greedy_policy, Ad=78, Action=Male, Reward=1
Iteration 10977: Policy=epsilon_greedy_policy, Ad=30, Action=Male, Reward=1
Iteration 10978: Policy=epsilon_greedy_policy, Ad=64, Action=Male, Reward=1
Iteration 10979: Policy=epsilon_greedy_policy, Ad=80, Action=Female, Reward=0
Iteration 10980: Policy=epsilon_greedy_policy, Ad=13, Action=Female, Reward=1
Iteration 10981: Policy=epsilon_greedy_policy, Ad=84, Action=Male, Reward=1
Iteration 10982: Policy=epsilon_greedy_policy, Ad=5, Action=Female, Reward=1
Iteration 10983: Policy=epsilon_greedy_policy, Ad=98, Action=Male, Reward=0
Iteration 10984: Policy=epsilon_greedy_policy, Ad=20, Action=Male, Reward=1
Iteration 10985: Policy=epsilon_greedy_policy, Ad=45, Action=Male, Reward=1
Iteration 10986: Policy=epsilon_greedy_policy, Ad=62, Action=Male, Reward=1
Iteration 10987: Policy=epsilon_greedy_policy, Ad=51, Action=Male, Reward=1
Iteration 10988: Policy=epsilon_greedy_policy, Ad=83, Action=Female, Reward=1
Iteration 10989: Policy=epsilon_greedy_policy, Ad=97, Action=Male, Reward=1
Iteration 10990: Policy=epsilon_greedy_policy, Ad=30, Action=Male, Reward=1
Iteration 10991: Policy=epsilon_greedy_policy, Ad=65, Action=Male, Reward=0
Iteration 10992: Policy=epsilon_greedy_policy, Ad=66, Action=Female, Reward=0
Iteration 10993: Policy=epsilon_greedy_policy, Ad=14, Action=Female, Reward=1
Iteration 10994: Policy=epsilon_greedy_policy, Ad=77, Action=Male, Reward=0
Iteration 10995: Policy=epsilon_greedy_policy, Ad=84, Action=Male, Reward=0
Iteration 10996: Policy=epsilon_greedy_policy, Ad=52, Action=Female, Reward=1
Iteration 10997: Policy=epsilon_greedy_policy, Ad=12, Action=Male, Reward=1
Iteration 10998: Policy=epsilon_greedy_policy, Ad=0, Action=Male, Reward=1
Iteration 10999: Policy=epsilon_greedy_policy, Ad=74, Action=Female, Reward=0
Iteration 11000: Policy=epsilon_greedy_policy, Ad=77, Action=Male, Reward=1
Average Rewards: [0.6720484359233098, 0.6713709677419355, 0.6717019133937563, 0.671026156941649
9, 0.6703517587939698, 0.6706827309236948, 0.6710130391173521, 0.6713426853707415, 0.67067067067
06707, 0.671]

Exploration Percentage: 0.2, Alpha: 0.2

Iteration 11001: Policy=epsilon_greedy_policy, Ad=74, Action=Male, Reward=1
Iteration 11002: Policy=epsilon_greedy_policy, Ad=13, Action=Male, Reward=1
Iteration 11003: Policy=epsilon_greedy_policy, Ad=34, Action=Male, Reward=1
Iteration 11004: Policy=epsilon_greedy_policy, Ad=80, Action=Female, Reward=0
Iteration 11005: Policy=epsilon_greedy_policy, Ad=6, Action=Male, Reward=1

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Iteration 11966: Policy=epsilon_greedy_policy, Ad=9, Action=Female, Reward=1
Iteration 11967: Policy=epsilon_greedy_policy, Ad=20, Action=Male, Reward=1
Iteration 11968: Policy=epsilon_greedy_policy, Ad=47, Action=Male, Reward=1
Iteration 11969: Policy=epsilon_greedy_policy, Ad=61, Action=Male, Reward=1
Iteration 11970: Policy=epsilon_greedy_policy, Ad=7, Action=Male, Reward=1
Iteration 11971: Policy=epsilon_greedy_policy, Ad=89, Action=Male, Reward=1
Iteration 11972: Policy=epsilon_greedy_policy, Ad=84, Action=Male, Reward=1
Iteration 11973: Policy=epsilon_greedy_policy, Ad=35, Action=Female, Reward=0
Iteration 11974: Policy=epsilon_greedy_policy, Ad=64, Action=Male, Reward=1
Iteration 11975: Policy=epsilon_greedy_policy, Ad=98, Action=Male, Reward=0
Iteration 11976: Policy=epsilon_greedy_policy, Ad=77, Action=Male, Reward=1
Iteration 11977: Policy=epsilon_greedy_policy, Ad=53, Action=Male, Reward=0
Iteration 11978: Policy=epsilon_greedy_policy, Ad=46, Action=Male, Reward=1
Iteration 11979: Policy=epsilon_greedy_policy, Ad=40, Action=Male, Reward=1
Iteration 11980: Policy=epsilon_greedy_policy, Ad=12, Action=Male, Reward=1
Iteration 11981: Policy=epsilon_greedy_policy, Ad=19, Action=Male, Reward=1
Iteration 11982: Policy=epsilon_greedy_policy, Ad=50, Action=Female, Reward=0
Iteration 11983: Policy=epsilon_greedy_policy, Ad=90, Action=Male, Reward=1
Iteration 11984: Policy=epsilon_greedy_policy, Ad=91, Action=Male, Reward=1
Iteration 11985: Policy=epsilon_greedy_policy, Ad=59, Action=Male, Reward=1
Iteration 11986: Policy=epsilon_greedy_policy, Ad=95, Action=Male, Reward=1
Iteration 11987: Policy=epsilon_greedy_policy, Ad=45, Action=Male, Reward=0
Iteration 11988: Policy=epsilon_greedy_policy, Ad=54, Action=Male, Reward=1
Iteration 11989: Policy=epsilon_greedy_policy, Ad=84, Action=Male, Reward=1
Iteration 11990: Policy=epsilon_greedy_policy, Ad=44, Action=Male, Reward=1
Iteration 11991: Policy=epsilon_greedy_policy, Ad=65, Action=Male, Reward=1
Iteration 11992: Policy=epsilon_greedy_policy, Ad=90, Action=Male, Reward=0
Iteration 11993: Policy=epsilon_greedy_policy, Ad=69, Action=Female, Reward=0
Iteration 11994: Policy=epsilon_greedy_policy, Ad=99, Action=Male, Reward=1
Iteration 11995: Policy=epsilon_greedy_policy, Ad=77, Action=Male, Reward=1
Iteration 11996: Policy=epsilon_greedy_policy, Ad=16, Action=Male, Reward=0
Iteration 11997: Policy=epsilon_greedy_policy, Ad=75, Action=Female, Reward=1
Iteration 11998: Policy=epsilon_greedy_policy, Ad=77, Action=Female, Reward=1
Iteration 11999: Policy=epsilon_greedy_policy, Ad=6, Action=Male, Reward=0
Iteration 12000: Policy=epsilon_greedy_policy, Ad=25, Action=Male, Reward=0
Average Rewards: [0.7134207870837538, 0.7127016129032258, 0.7119838872104733, 0.712273641851106
6, 0.7125628140703517, 0.7118473895582329, 0.7121364092276831, 0.7124248496993988, 0.71171171171
17117, 0.711]

Exploration Percentage: 0.2, Alpha: 0.3

Iteration 12001: Policy=epsilon_greedy_policy, Ad=74, Action=Male, Reward=0
Iteration 12002: Policy=epsilon_greedy_policy, Ad=75, Action=Female, Reward=1
Iteration 12003: Policy=epsilon_greedy_policy, Ad=61, Action=Female, Reward=1
Iteration 12004: Policy=epsilon_greedy_policy, Ad=50, Action=Male, Reward=1
Iteration 12005: Policy=epsilon_greedy_policy, Ad=59, Action=Male, Reward=1
Iteration 12006: Policy=epsilon_greedy_policy, Ad=33, Action=Female, Reward=1
Iteration 12007: Policy=epsilon_greedy_policy, Ad=65, Action=Male, Reward=1
Iteration 12008: Policy=epsilon_greedy_policy, Ad=90, Action=Male, Reward=1
Iteration 12009: Policy=epsilon_greedy_policy, Ad=66, Action=Male, Reward=1
Iteration 12010: Policy=epsilon_greedy_policy, Ad=81, Action=Male, Reward=1
Iteration 12011: Policy=epsilon_greedy_policy, Ad=87, Action=Male, Reward=1
Iteration 12012: Policy=epsilon_greedy_policy, Ad=14, Action=Male, Reward=1
Iteration 12013: Policy=epsilon_greedy_policy, Ad=20, Action=Male, Reward=1
Iteration 12014: Policy=epsilon_greedy_policy, Ad=67, Action=Male, Reward=0
Iteration 12015: Policy=epsilon_greedy_policy, Ad=40, Action=Male, Reward=1
Iteration 12016: Policy=epsilon_greedy_policy, Ad=77, Action=Male, Reward=1
Iteration 12017: Policy=epsilon_greedy_policy, Ad=28, Action=Male, Reward=1
Iteration 12018: Policy=epsilon_greedy_policy, Ad=78, Action=Male, Reward=0
Iteration 12019: Policy=epsilon_greedy_policy, Ad=93, Action=Female, Reward=0
Iteration 12020: Policy=epsilon_greedy_policy, Ad=49, Action=Male, Reward=1
Iteration 12021: Policy=epsilon_greedy_policy, Ad=10, Action=Male, Reward=1
Iteration 12022: Policy=epsilon_greedy_policy, Ad=37, Action=Male, Reward=1
Iteration 12023: Policy=epsilon_greedy_policy, Ad=64, Action=Female, Reward=0
Iteration 12024: Policy=epsilon_greedy_policy, Ad=7, Action=Male, Reward=0

[illegible]

[illegible]

[illegible]

[illegible]

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[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

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Iteration 12985: Policy=epsilon_greedy_policy, Ad=23, Action=Male, Reward=1
Iteration 12986: Policy=epsilon_greedy_policy, Ad=89, Action=Female, Reward=1
Iteration 12987: Policy=epsilon_greedy_policy, Ad=13, Action=Male, Reward=1
Iteration 12988: Policy=epsilon_greedy_policy, Ad=44, Action=Male, Reward=0
Iteration 12989: Policy=epsilon_greedy_policy, Ad=20, Action=Male, Reward=0
Iteration 12990: Policy=epsilon_greedy_policy, Ad=62, Action=Female, Reward=1
Iteration 12991: Policy=epsilon_greedy_policy, Ad=34, Action=Male, Reward=1
Iteration 12992: Policy=epsilon_greedy_policy, Ad=67, Action=Male, Reward=1
Iteration 12993: Policy=epsilon_greedy_policy, Ad=62, Action=Male, Reward=1
Iteration 12994: Policy=epsilon_greedy_policy, Ad=95, Action=Male, Reward=1
Iteration 12995: Policy=epsilon_greedy_policy, Ad=0, Action=Female, Reward=1
Iteration 12996: Policy=epsilon_greedy_policy, Ad=51, Action=Female, Reward=0
Iteration 12997: Policy=epsilon_greedy_policy, Ad=70, Action=Male, Reward=1
Iteration 12998: Policy=epsilon_greedy_policy, Ad=94, Action=Male, Reward=1
Iteration 12999: Policy=epsilon_greedy_policy, Ad=83, Action=Male, Reward=0
Iteration 13000: Policy=epsilon_greedy_policy, Ad=35, Action=Male, Reward=1
Average Rewards: [0.6881937436932392, 0.688508064516129, 0.6888217522658611, 0.6891348088531187,
0.6894472361809045, 0.6887550200803213, 0.6890672016048145, 0.6893787575150301, 0.68868868868868
87, 0.689]
```

Results and Discussion

Impact of Exploration Percentage (EXPLORE_PERCENTAGE) Low Exploration Percentage (e.g., 0.1): The algorithm primarily exploits actions with higher estimated rewards. This can lead to faster convergence to local optima but may miss potentially better actions.

Medium Exploration Percentage (e.g., 0.15): Increases exploration, allowing the algorithm to discover better actions over time while still exploiting known good actions. This balance often yields better overall performance compared to lower exploration percentages.

High Exploration Percentage (e.g., 0.2): Intensifies exploration, leading to more frequent testing of new actions. While this can lead to discovering better actions in the long run, it may initially result in lower average rewards due to increased exploration.

Impact of Alpha (α)

Lower Alpha (e.g., 0.1): Slower to update action value estimates, which can result in slower convergence but more stable learning over time.

Higher Alpha (e.g., 0.3): Faster updates to action value estimates, allowing the algorithm to adapt more quickly to new information. This can lead to faster initial learning but may also result in more fluctuation in estimates.

Conclusion (0.5M)

Conclude your assignment in 250 words by discussing the best approach for maximizing the CTR using random, greedy, epsilon-greedy and UCB.

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In the realm of digital advertising, maximizing Click-Through Rate (CTR) is paramount for ensuring effective engagement and conversion of users. Various Multi-Arm Bandit (MAB) algorithms—random, greedy, epsilon-greedy, and UCB—offer distinct strategies to optimize CTR while balancing exploration of new ad strategies and exploitation of proven high-performing ads.

Random Policy: Randomly selects ads without regard to their performance, serving as a baseline for comparison. While simple and unbiased, it lacks efficiency in learning and optimizing CTR, often leading to suboptimal results due to the absence of any strategic decision-making based on past performance.

Greedy Policy: Exploits the currently perceived best-performing ad based on historical data. This approach tends to converge quickly to a locally optimal solution but risks missing out on potentially better-performing ads if initial estimates are inaccurate or if exploration is insufficient.

Epsilon-Greedy Policy: Balances exploration and exploitation by choosing the best-performing ad most of the time (exploitation) while occasionally exploring other ads at a rate controlled by ϵ (exploration percentage). This flexibility allows the algorithm to continuously learn and adapt, striking a balance between exploiting known high-performing ads and exploring new opportunities to improve CTR.

UCB (Upper Confidence Bound) Policy: Uses uncertainty estimates to decide between exploiting the best-known option and exploring potentially better options. By maintaining a balance between exploration and exploitation through dynamically adjusting confidence intervals, UCB often achieves a more robust performance compared to other algorithms in terms of maximizing CTR.

Best Approach for Maximizing CTR: The choice of the best approach—random, greedy, epsilon-greedy, or UCB—depends on the specific goals and constraints of the advertising campaign:

Initial Exploration: If initial data is scarce or uncertain, a higher exploration strategy like epsilon-greedy or UCB can rapidly explore and identify potentially high-performing ads.

Stable Exploitation: Once reliable performance data accumulates, transitioning towards a more exploitative strategy (greedy or UCB) helps in consistently maximizing CTR based on established trends.

Dynamic Adjustment: Epsilon-greedy and UCB algorithms offer flexibility in dynamically adjusting exploration rates based on evolving campaign goals and market conditions, making them suitable for adaptive advertising strategies.

In conclusion, while each MAB algorithm offers unique advantages, epsilon-greedy and UCB stand out for their ability to balance exploration and exploitation effectively over time, thereby maximizing CTR in digital advertising campaigns. By leveraging these adaptive strategies, advertisers can optimize engagement, conversions, and ultimately, revenue generation from their digital ads.

In []: