**Project Report:**

**Task-Worker Assignment Scenario 1: Greedy and Game-Theoretic Approaches for complete information workers**

**1. Introduction**: The purpose of this project is to address the task-worker assignment problem by maximizing the overall satisfaction score. The problem involves assigning workers to tasks while considering various constraints such as location, skills, range, budget, and travel costs. To tackle this problem, two approaches have been implemented: the Greedy algorithm and the Game-Theoretic approach. This report aims to present an overview of these approaches and compare their performance based on different metrics.

**2. Problem Description**: The task-worker assignment problem aims to maximize the expected overall satisfaction score, which is calculated based on price satisfaction and cooperation satisfaction. The satisfaction score can be expressed as the sum of the price satisfaction and cooperation satisfaction, where price satisfaction is determined by the budget of the task minus the sum of worker costs multiplied by the distance between the worker and the task. Cooperation satisfaction is calculated as the average of the possible cooperation score pairs among the assigned workers.

Each worker is represented by a 4-tuple (L, K, R, v), where L denotes the worker's location, K represents their skill set, R represents the worker's range, and v denotes the unit cost of travel for the worker. Similarly, each task is represented by a 4-tuple (L, K, B, D), where L represents the task's location, K represents the required skill set, B represents the budget or reward for completing the task, and D represents the task's expiry date.

The problem encompasses these constraints:

* The task must be located within the worker's working range.
* The worker must possess at least one skill required to complete the task.
* Each worker can only be assigned to one task at a time.
* The total travel cost must not exceed the task's budget.

The objective is to find an optimal assignment of task-worker pairs that maximizes the expected overall satisfaction score. The satisfaction score is a combination of price satisfaction and cooperation satisfaction, which takes into account both the economic factors and the degree of worker cooperation. Price satisfaction is influenced by the budget and the cost of travel for each worker, while cooperation satisfaction considers the extent to which workers cooperate with each other.

By formulating the problem in this way, we consider not only the economic efficiency of the assignment but also the importance of collaboration among workers. The assignment algorithm needs to strike a balance between minimizing costs and promoting effective cooperation among workers, ultimately maximizing the overall satisfaction score.

**3. Greedy Approach:** The Greedy algorithm begins by greedily assigning workers to tasks, considering the satisfaction score. If a valid assignment is possible, the algorithm assigns the worker to the task, incrementing the satisfaction score. Additionally, conflict workers in different worker sets corresponding to different tasks are resolved by keeping the worker in the set that yields a greater satisfaction increment.

For unassigned workers, singleton worker sets are created for tasks with the highest satisfaction score. If a worker cannot be assigned, they are placed in an 'unassigned' set. The algorithm removes the task from the task set and the worker from the worker set accordingly. The resulting assignment and unassigned workers are returned for further processing.

**4. Game-Theoretic Approach:** The Game-Theoretic approach builds upon the initial assignment obtained from the Greedy algorithm. The problem is modelled as a game, where each worker's strategy is to select a task to work on, and the increase in satisfaction score serves as their payoff.

Using the Nash Equilibrium concept, the optimal strategy for each worker is determined. The algorithm continues until a Nash Equilibrium is reached. During each iteration, an unassigned worker is selected and swapped with one of the assigned workers, considering the highest positive satisfaction score increment (payoff). This process aims to improve the overall satisfaction score by iteratively optimizing the assignment.

**5. Comparison Metrics:** To evaluate and compare the performance of the Greedy and Game-Theoretic approaches, the following metrics have been considered:

* Time taken to run the algorithm: This metric measures the computational efficiency of each approach.
* Number of assigned workers: Indicates the utilization of workers in the assignment process.
* Total satisfaction score: Represents the overall satisfaction achieved by the assignment.

**6. Results and Conclusion till part 1**: In this project, we presented two approaches, Greedy and Game-Theoretic, to solve the task-worker assignment problem. The Greedy algorithm provides an initial assignment based on satisfaction score increments, while the Game-Theoretic approach optimizes the assignment using the concept of Nash Equilibrium.

The comparison of the two approaches based on metrics such as time taken, number of assigned workers, and total satisfaction score will provide insights into their performance. The next part of this project will delve into the evaluation of these metrics for different parameters such as the number of workers, tasks, range of workers, budget of tasks, skill set of tasks, and cost of worker travel.

Overall, the first part of the project lays the foundation for solving the task-worker assignment problem and presents two approaches to optimize the assignment process. The second part of the report will delve into the evaluation of the algorithms based on the specified parameters. By combining both parts, a comprehensive understanding of the project and its findings can be obtained.

**Task-Worker Assignment Scenario 2: Greedy and Game-Theoretic Approaches for in complete information workers**

**1. Incomplete Information:** In the second part of the project, we encounter incomplete information about some of the workers' skills. Specifically, certain workers have probabilistic skills, where the worker's skill set is associated with probabilities indicating the likelihood of possessing each skill. For instance, a worker might have a skill set of {1, 2, 3} with corresponding probabilities {0.2, 0.3, 0.4}. This implies that the worker has a 0.2 probability of having skill 1 and a 0.8 probability of not having skill 1. Similarly, the probabilities apply to the other skills in the worker's skill set.

To account for the probabilistic nature of the workers' skills, we consider all possibilities for the worker's skill set along with the corresponding probabilities for each possibility. This approach allows us to compute the values of the metrics for each possibility and subsequently calculate the expected value of each metric. By considering the expected values, we can assess the algorithms' performance under incomplete information.

**2. Comparison Metrics:** In evaluating and comparing the algorithms, we focus on the expected values of the metrics. The metrics considered remain the same as in the first part of the project and include the number of assigned workers, total satisfaction score, and cooperation satisfaction.

However, we introduce a distinction regarding the time taken for each algorithm to run. Due to the nature of the overall algorithm, where both the Greedy and Game-Theoretic approaches are run alternately for all possibilities, it is not feasible to compute the time taken separately. Hence, we directly plot the total time taken to run both algorithms, omitting the individual time taken for each.

By comparing the expected values of the metrics, we can assess the algorithms' performance under incomplete information and gain insights into their effectiveness in optimizing the task-worker assignment process.

**Final Conclusion:**

The second part of the project introduces the challenge of incomplete information about workers' skills by incorporating probabilistic skill sets. To address this, we consider all possibilities for the worker skill sets along with their corresponding probabilities. By computing the expected values of the metrics, we can evaluate and compare the performance of the Greedy and Game-Theoretic algorithms under incomplete information.

The comparison metrics, constraints, and algorithms used in the second part align with those of the first part. However, the evaluation focuses on the expected values of the metrics, with the total time taken to run both algorithms plotted rather than considering individual runtime.

By combining the insights from both parts of the project, we will obtain a comprehensive understanding of the task-worker assignment optimization problem, considering both complete and incomplete information scenarios.