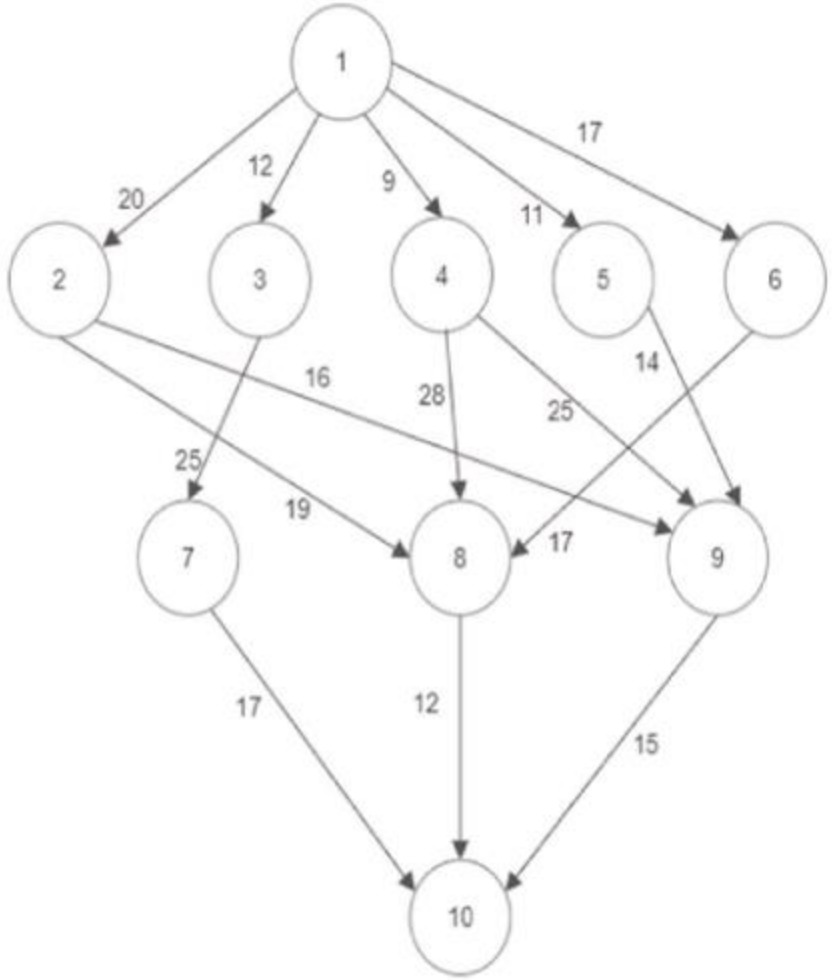
Implementation of
ACO-based algorithm for task scheduling in heterogeneous multiprocessing environments

Problem

- Scheduling in multiprocessing environment
  - GPU, CPU, TPU
  - Different speeds and communication times
- NP-hard



Ant Colony Optimization

An efficient ACO-based algorithm for task scheduling in heterogeneous multiprocessing environments

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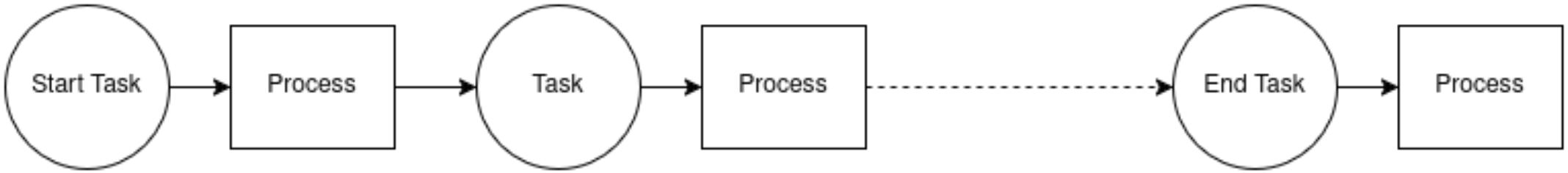
The ACO Metaheuristic

Set parameters, initialize pheromone trails
while termination condition not satisfied **do**
    Construct Ant Solutions
    Apply Local Optimization (optional)
    Pheromone Update
end while

Fig. 1. The aco metaheuristic.

An ant solution



While there are tasks remaining

- Ant decides the next ready task
    - task where all its dependencies are assigned a process
- Ant decides the process for the task

Pheromone Matrices

- 2 pheromone matrices
- Contains pheromone for edges from Process to Task
- Contains pheromone for edges from Task to Process

Deciding Task and Process

- First iteration, decides at random task and process
- Subsequent iterations
  - Decides task based on STaskRule
  - Decides task based on SProcRule

STaskRule

$$\text{Task Heuristic} = \frac{\text{Phermone[Process,Task]}}{\text{Longest Path from Task to End}}$$

$$\text{Probability Mass Density(Task)} = \frac{\text{Task Heuristic}}{\text{Sum of All Next Tasks Heuristic}}$$

SProcRule

$$\text{Process Heuristic} = \frac{\text{Pheromone[Task,Process]}}{\text{Average Computation Cost of Task} \times \text{Estimate Start Time}}$$

$$\text{Probability Mass Density(Process)} = \frac{\text{Process Heuristic}}{\text{Sum of All Process Heuristics}}$$

Pheromone Update

- Local Pheromone Update: Pick some best ant solutions

$$\text{Gained Pheromone} = \frac{1}{\text{Completed Time}}$$

$$\text{New Pheromone} = (1 - \text{Decay}) \times \text{Old Pheromone} + \text{Gained Pheromone}$$

- Global Pheromone Update: Pick 1 best ant solution

$$\text{New Pheromone} = (1 - \text{Decay}) \times \text{Old Pheromone} + \text{Decay} \times \text{Gained Pheromone}$$

Aging Pheromone

- If the best solution is not changing (Stagnation)
  - Randomize the pheromones in the matrices, so that it is less or equal to the old pheromones
  - All ants begin to pick processes and tasks randomly as if it is the first iteration.

Limitation

- Many parameters
  - Number of ants, number of best ants, number of iterations, process heuristic, task length heuristics, decay parameter
- No guarantee of optimality

Demo