



Candidate evaluation

Swarm Analyst

Introduction

This document describes tasks for evaluating candidates applying for the *Swarm Analyst* position at Gideon Brothers. The candidate should solve the problems described in the sequel independently representing her/his expertise and skills adequate for the respective position.

Main task

Goal:

The candidate should demonstrate his/her **analytical and presentation capabilities**. The candidate is given a large amount of data obtained from a **swarm simulator** and is expected to interpret the data, draw conclusions, and present findings through graphs and bullet points.

About Swarm system:

Gideon Brothers' Swarm system is a heterogeneous system of autonomous mobile robots (**AMRs**) and human operators (**pickers**) working together in a warehouse environment on order picking operations. In this system, the robots are responsible for **transporting pallets** throughout the facility, and the humans are responsible for **placing items** from the shelf positions to the pallets carried by the robots. An order is a list of items that need to be picked and packed onto a single pallet and transported to the outbound area. Given a list of orders, the Fleet Management System (**FMS**) assigns each order to a single robot. When a robot is assigned an order, the robot takes an empty pallet from an input station and starts **visiting the items' locations** associated with the assigned order. The FMS then assigns a human picker for each order item. The FMS communicates with the human operators through a smart device and gives the commands for the next item to be picked.

About Swarm data file:

The candidate is given an Excel file in which simulation data is stored. Each row in the file represents a **simulation run**, which is executed with a different number of robots (5-50) and human pickers (5-25). For each simulation run, we recorded various **data about human and robot operations**, e.g., how much time robots and humans spent moving, waiting, assisting, etc. (total time and average time per robot/human). The file also contains the two most important values of each simulation: **cost-saving percentage and throughput factor**. The cost-saving percentage represents how much is the Swarm system cheaper (positive percentage) or more expensive (negative percentage) than the human only system executing the same order tasks. The throughput factor shows how much less time (factor > 1) or more time (factor <= 1) is required for the Swarm system to execute the same tasks as the human-only system.

Task:

The candidate **should examine the given file and prepare several graphs** that visually depict the data. The candidate can use Excel tools to prepare graphs or any other software that can import Excel files and has plotting capabilities. The candidate should also present his/her conclusions about each graph

in the form of bullet points. The candidate is encouraged to use different colors and arrows on the graphs to depict observed trends. Specifically, the candidate should present the following graphs.

1. **Throughput factor vs robot/picker ratio.**
The robot/picker ratio is a ratio between the robots' number and pickers' number used in a particular simulation.
Which robot/picker ratio should one use to obtain the maximum system throughput?
2. **Cost-saving percentage vs robot/picker ratio.**
Which robot/picker ratio should one use to obtain the maximum cost savings?
3. Depict a **trade-off between throughput factor and cost-saving percentage** when choosing the number of robots and pickers.
Which Swarm size (number of robots and pickers) would you recommend to obtain a solid throughput factor with reasonable cost savings?
4. How pickers spend their working hours in the Swarm system? There are three actions that the pickers execute in the simulation: moving (walking to the next item position), waiting (waiting for the robot to reach the item location), and assisting (picking and placing the item on the robot's pallet). Depict **the pickers' actions percentages vs robot/picker ratio** on a single graph.
5. How robots spend their working hours in the Swarm system? There are four robots actions in the simulation: moving (driving to the next item position or input/output stations), waiting (waiting for the picker to reach the item location, waiting in the traffic or input/output station queue), assisting (standing still at the item location to allow the picker to place the item on the pallet) and lifting/dropping pallets (time for lifting empty pallets at input stations and dropping loaded pallets as output stations). Depict **the robots' actions percentages vs robot/picker ratio** on a single graph.
6. Prepare any other graphs that you might find interesting.

The form of a report:

A pdf file with graphs and candidates' findings in the form of bullet points.

General information

Deadline: The candidate should finish the tasks within **5 days**.

Note: If the candidate encounters any difficulties in the assignment solving process, the one is expected to communicate them as quickly as possible.