Job-Shop Scheduling Problem Simulation using Arena

This project features a detailed simulation model of a job-shop manufacturing system built with Rockwell Arena. The simulation addresses a classic scheduling problem involving multiple job types, each with a unique processing sequence and machining time across a shared set of resources.

📝 Problem Statement

The system models a production unit where four distinct types of jobs arrive for processing. The jobs are: **Bolt, Nut, Gear, and Plug**. These jobs arrive with inter-arrival times of 1, 2, 2.5, and 1.5 minutes, respectively. Each job type follows a specific routing sequence through seven different processing stations.

Job Sequences & Machining Times

The detailed routing and the time (in minutes) required at each machine are outlined below:

Job	Job Sequence
Bolt	Turning (3) → Threading (10) → Cutting off (2) → Grinding (6) → Finishing (2)
Nut	Turning (2) → Drilling (2) → Grinding (6) → Cutting off (2) → Threading (7) → Finishing (2)
Gear	Turning (10) → Grinding (2) → Milling (20) → Cutting off (2) → Drilling (2) → Finishing (3)
Plug	Turning (3) → Threading (10) → Drilling (2) → Cutting off (2) → Grinding (6) → Finishing (2)

🎯 Project Objectives

The primary goals of this simulation study are:

1. **Develop a Model:** To accurately construct a simulation model of the described job-shop manufacturing system using Arena.

2. **Simulate & Visualize:** To run the simulation to observe the system's behavior, identify potential bottlenecks, and visualize the flow of jobs.
3. **Measure Performance:** To calculate and analyze key performance indicators (KPIs) such as **makespan** and **cycle time** to evaluate system efficiency.

🛠️ Model Details & System Logic

Here is a breakdown of the components and logic used to build the Arena model:

- **System Requirements:** Windows OS and Rockwell Arena simulation software.
- **Entities:** Four distinct entities representing each job type (Part 1, Part 2, Part 3, and Part 4).
- **Resources:** The machines required for processing, including:
  - Turning Machine
  - Grinding Machine
  - Milling Machine
  - Cutting Machine
  - Drilling Machine
  - Threading Machine
  - Finishing Machine
- **Process Logic:** The core action for all machining processes is **Seize Delay Release**, where a job seizes a machine, is delayed for the required processing time, and then releases the machine.
- **Queue Discipline:** All queues operate on a **First-Come, First-Served (FCFS)** basis.
- **Stations:** The model is built using stations to represent the different machining locations:
  - Station T (Turning)
  - Station Th (Threading)
  - Station C (Cutting)
  - Station M (Milling)
  - Station D (Drilling)
  - Station F (Finishing)
  - Station E (Exit/Dispose)

Arena Modules Used

The simulation model was constructed using the following standard Arena modules:

- **Create:** To generate the arrival of the four job types.
- **Assign:** To set attributes for each entity, such as job type and processing times.
- **Station:** To define the different workstations in the system.
- **Process:** To model the machining operations (Seize-Delay-Release).
- **Route:** To direct entities between stations according to their unique job sequences.
- **Dispose:** To remove completed jobs from the system.
- *Other supporting modules as necessary.*

🚀 How to Run the Simulation

1. Ensure you have **Rockwell Arena** installed on a **Windows** operating system.
2. Clone this repository or download the .doe model file.
3. Open the file in Arena.
4. Run the simulation to observe the model and generate the results report.

📊 Results & Analysis

After running the simulation, a comprehensive report will be generated by Arena. The key metrics to analyze from this report are the **makespan** (total time to complete all jobs) and the **average cycle time** for each job type. These results will provide insights into the system's throughput, efficiency, and resource utilization.