Developing an Adaptive Scheduling System for Production-Inventory Replenishment Problems

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Research Motivation
Problem Statement

• Manufacturing plan and schedule production process; allocate resources for smooth running of production shop floor
• Changing customer requirements causes disruption and make it complex task.
• “Traditionally, manufacturing production systems were not designed to be responsive, flexible and reconfigurable because, they were built on rigid, centralised and hierarchical control structures that present good production optimisation but a weak response to change” (Alsina et al. 2004).
• Maintaining optimum inventory level becomes a challenge manufacturers.
• Customers satisfaction remain priority
• For this reason, an adaptive system which will not only respond to changes based on customer demand requirement but also facilitate production and inventory system operations is required.
• In my research, I am investigating the effect of this customer changing requirements on production on-time delivery, while maintaining production process disruption to the minimal.
Changing Requirements

- Demand sequence
- Due date
- Cancellation
Related Works

Alsina, Cabri and Regattieri (2004) present an agent-based model that simulates variation in production rates and failure prone of production lines by considering machine breakdown and suggested repair and maintenance.

Shen et al. (2005) propose a shop floor control system implemented to respond quickly to changing shop floor environments and customer demands using internet-enabled agent-based intelligent shop floor.

Similar to Lin et al (2010) that study the influence of customer on quality level and material specification for finished products, the current research is however considering the influence of customer on product sequence and quantity.

Unlike Rasti-Barzoki and Hejazi (2013) that addressed scheduling problem for batch delivery of products to multiple customers, the current research is considering the problem of sequence delivery in respond to customers’ continuous changing requirements

Also, Lozano and Medaglia (2014) consider sequence-dependent processing time, batch capacity constraint, machine capacity, incompatible product families and additional resources all related to parallel machine workstation.

Unlike Lozano and Medaglia (2014), this research is adding additional constraint on demand sequence from customer, affecting the constraints already considered in Lozano and Medaglia (2014).

Also, Surjandari et al. (2015) focus on scheduling of parallel machine with sequence-dependent batch and product incompatibilities in bottleneck workstation to maximise utilisation and minimise delay
Proposed Approach

• Proposed (Innovative) Framework
• Adaptive Heuristic
• Multi-Agent System (Using Excel VBA)
• Production-Inventory Replenishment Strategy
Tools & Techniques

• Literature review
• Logical modelling techniques such as; UML diagrams, flowchart, sequence diagram
• On site visit, Observation, Interviews
• Heuristic Algorithm
• Multi-Agent Simulation Approach using MS Excel VBA
• Case study with the Unipart Manufacturing (UEES)
Deliverables

- A comprehensive review of literatures in the area of production scheduling including customer demand sequence, production and inventory repair
- A collection of related logical diagrams
- A collection of manufacturing production data
- Multi-agent-based Simulation Model
- Adaptive heuristic Algorithm
- A simulation-based heuristic production-Inventory repair model
System Components/Modules

Scheduling Process Time chart
- Reveals sequence and quantity change
- Reveals number of setups
- Identifies when to borrow
- Detects free slot to replenish

Multi-Agent System Interaction
- Includes individual agents (order, machine, operator)
- Communicates useful information such as agents attributes and behaviour, process time, setup time, due date etc.

Messaging Sequence
- Collaborate the system
- Receives message
- Sends feedback
- Update information
Production-Inventory Replenishment Strategy
Case Study with Unipart Manufacturing (UEES)

- Real-life Manufacturing Environment
- Collaboration
- Data Collection
- Experimentation
- System Implementation
- System Verification and Validation
Multi-Agent Based System Dashboard
Input Parameter Form

Adaptive Manufacturing Shop Floor Simulation Modelling

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Machines</th>
<th>Operators</th>
<th>Orders</th>
<th>Heuristic Algorithm</th>
<th>Modelling Rules</th>
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Shop Floor Working Hours
- Monday to Friday
- From: 08:00
- To: 19:00
- Current Day: 12/01/2017

Run Simulation  Open Dashboard  Open Dashboard Graph
Open Result Table  Open Result Graph  Open Result Gantt
Machine Input
Operator Input
Order Input

Adaptive Manufacturing Shop Floor Simulation Modelling

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Machines</th>
<th>Operators</th>
<th>Orders</th>
<th>Heuristic Algorithm</th>
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Number of Parts (Items)

<table>
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Order Start and End Date/Time

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Run Simulation  Open Dashboard  Open Dashboard Graph  Open Result Table  Open Result Graph  Open Result Gantt

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System Rules

Adaptive Manufacturing Shop Floor Simulation Modelling

Rules for Orders
- [ ] Earliest Due Date
- [ ] Highest Percentage Processed
- [ ] Least Percentage Processed
- [X] Highest Idle Time

Rules for Machines
- [ ] Least Processing Time in Queue
- [X] Least Number of Parts in Queue
- [ ] Highest Idle Time

Rules for Operators
- [X] Least Utilisation (%)
Dashboard Graph

Machine Usage (%)

Operator Usage (%)

Order Completion (%)

Machine Time (Mins)

Operator Time (Mins)

Order Time (mins)

Machine Queue Size (In Order)
Result Graph

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## Result Table

![Excel Spreadsheet](image_url)
## Order Data

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*Source: Coventry University*
Research Benefits

- ‘Smooth’ production process
- Effective utilisation of resources
- Manufacturing competitiveness
- Enhance productivity
Next Steps

- Implement heuristic algorithm
- Add inventory facility
- Include and experiment different scenarios
- Generate and analyse results
Thank You