OPTIMIZATION OF ROUTING AND SCHEDULING LAYOUT BY USING FLEXSIM

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ABSTRACT

Routing refers to mapping routes for delivery agents or field executives to ensure the deliveries mentioned above happen on time. Scheduling can be defined as the method to plan time intervals for delivery executives to make assigned deliveries. FlexSim is a discrete-event simulation software package developed by FlexSim Software Products, Inc. The FlexSim product family currently includes the general purpose FlexSim product and healthcare systems modeling environment (FlexSim HC).
Using the different resources, talk executers and parameters. Build a model that uses lists for routing items in a simple job shop model. In this model 3 different types of products, designed by items type. Each type has a unique sequence of operations that must be performed on the part before it is finished. Bottleneck problem is identified at Queue 1, Optimization has been done for the layout to minimize the stock waiting in the Queue 1. Flexsim 2022 software is used to optimize the layout.
Keyword: - *Optimization, Flexsim, Routing and Scheduling.*

1. INTRODUCTION

Routing is the process of creating the most cost effective route through minimization of distance or travel time necessary in order to reach a set of planned stops. Routing is a crucial process of logistics systems, especially due to the high competition and narrowing margins in the global market. Routing of goods and services incurs huge costs for vehicle operation, fuel, labor, and maintenance. Route scheduling is the process of assigning an arrival and service time for each stop, with drivers being assigned shifts that adhere to working hours. The entire objective of both routing and route scheduling is to effectively cut down on your expenses, such as mileage and vehicle capital costs. Route optimization is the process of planning one or multiple routes, with the purpose of minimizing overall costs, while achieving the highest possible performance under a set of given constraints.
In other way, routing means determination of most advantageous path to be followed from department to department and machine to machine till raw material gets its final shape, which involves the following steps:

- Type of work to be done on product or its parts.
- Operation required to do the work.
- Sequence of operation required.
- Where the work will be done.
- A proper classification about the personnel required and the machine for doing the work.
- For effective production control of a well-managed industry with standard conditions, the routing plays an important role, i.e., to have the best results obtained from available plant capacity. Thus routing provides the basis for scheduling, dispatching and follow-up.

1.1: Techniques of Routing

While converting raw material into required goods different operations are to be performed and the selection of a particular path of operations for each piece is termed as 'Routing'. This selection of a particular path, i.e. sequence of operations must be the best and cheapest to have the lowest cost of the final product. The various routing techniques are:

Route card: This card always accompanies with the job throughout all operations. This indicates the material used during manufacturing and their progress from one operation to another. In addition to this the details of scrap and good work produced are also recorded

Work sheet: It contains

- Specifications to be followed while manufacturing.
- Instructions regarding routing of every part with identification number of machines and this sheet is made for manufacturing as well as for maintenance.

Route sheet: It deals with specific production order. Generally made from operation sheets. One sheet is required for each part or component of the order. This includes the following:

a) Number and other identification of order.
b) Symbol and identification of part.
c) Number of pieces to be made.
d) Number of pieces in each lot if put through in lots.
e) Operation data which includes:
   i. List of operation on the part.
   ii. Department in which operations are to be performed.
   iii. Machine to be used for each operation.
   iv. Fixed sequence of operation, if any.

Move order: Though this is document needed for production control, it is never used for routing system. Move order is prepared for each operation as per operation sheet. On this the quantity passed forward, scrapped and to be rectified are recorded. It is returned to planning office when the operation is completed.

Advantages of production routing

i. Effective utilization of available resources
ii. Reduction in production costs
iii. Quality improvement occurs
iv. The productivity of the system improves
v. Provides a basis for loading scheduling

1.2: Scheduling

Scheduling can be defined as “prescribing of when and where each operation necessary to manufacture the product is to be performed.” It is also defined as “establishing of times at which to begin and complete each event or operation comprising a procedure”. The principle aim of scheduling is to plan the sequence of work so that production can be systematically arranged towards the end of completion of all products by due date.

Principles of Scheduling

1. The principle of optimum task size: Scheduling tends to achieve maximum efficiency when the task sizes are small, and all tasks of same order of magnitude.
2. Principle of optimum production plan: The planning should be such that it imposes an equal load on all plants.
3. Principle of optimum sequence: Scheduling tends to achieve the maximum efficiency when the work is planned so that work hours are normally used in the same sequence.

Inputs to Scheduling

1. Performance standards: The information regarding the performance standards (standard times for operations) helps to know the capacity in order to assign required machine hours to the facility.
2. Units in which loading and scheduling is to be expressed.
3. Effective capacity of the work centre.
4. Demand pattern and extent of flexibility to be provided for rush orders.
5. Overlapping of operations.
6. Individual job schedules.

Scheduling Strategies

Scheduling strategies vary widely among firms and range from ‘no scheduling’ to very sophisticated approaches. These strategies are grouped into four classes:

1. Detailed scheduling: Detailed scheduling for specific jobs that are arrived from customers is impracticable in actual manufacturing situation. Changes in orders, equipment breakdown, and unforeseen events deviate the plans

2. Cumulative scheduling: Cumulative scheduling of total work load is useful especially for long range planning of capacity needs. This may load the current period excessively and under load future periods. It has some means to control the jobs.
3. Cumulative detailed: Cumulative detailed combination is both feasible and practical approach. If master schedule has fixed and flexible portions.
4. Priority decision rules: Priority decision rules are scheduling guides that are used independently and in conjunction with one of the above strategies, i.e., first come first serve. These are useful in reducing Work-In-Process (WIP) inventory.

Types of Scheduling

Types of scheduling can be categorized as forward scheduling and backward scheduling.

1. ***Forward scheduling:*** It is commonly used in job shops where customers place their orders on "needed as soon as possible" basis. Forward scheduling determines start and finish times of next priority job by assigning it the earliest available time slot and from that time, determines when the job will be finished in that work centre. Since the job and its components start as early as possible, they will typically be completed before they are due at the subsequent work centers in the routing. The forward method generates in the process inventory that are needed at subsequent work centers and higher inventory cost. Forward scheduling is simple to use and it gets jobs done in shorter lead times, compared to backward scheduling.
2. ***Backward scheduling***: It is often used in assembly type industries and commit in advance to specific delivery dates. Backward scheduling determines the start and finish times for waiting jobs by assigning them to the latest available time slot that will enable each job to be completed just when it is due, but done before. By assigning jobs as late as possible, backward scheduling minimizes inventories since a job is not completed until it must go directly to the next work centre on its routing. Forward and backward scheduling methods are shown in the following figure.

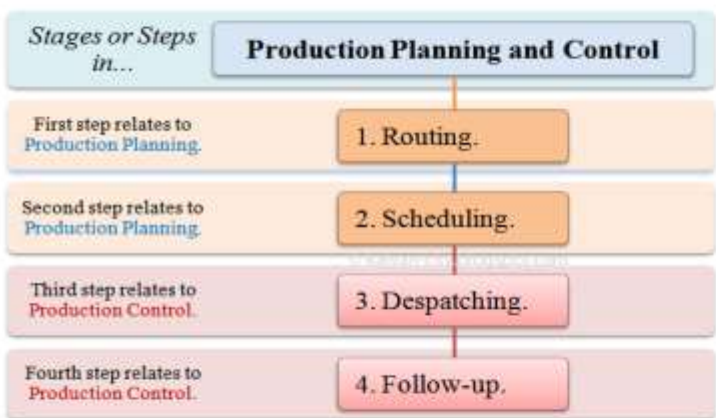


Figure 1.1: Routing and Scheduling

1.3: Flexsim software

FlexSim is 3D simulation software that models, simulates, predicts, and visualizes business systems in a variety of industries: manufacturing, material handling, healthcare, warehousing, mining, logistics, and more. It is both powerful and user-friendly.

FlexSim was founded in 1993 by Bill Nordgren (Co-Founder, ProModel Corporation, 1988), Roger Hullinger, and Cliff King, originally under the name F&H Simulations, Inc. F&H Simulations sold, supported, and conducted training courses for Taylor II simulation software—which was owned and developed by Holland's F&H Simulation B.V (F&H Holland).

In 1998, F&H Holland developed the first-generation 3D object-oriented simulation engine Taylor ED (Enterprise Dynamics). F&H Simulations assisted with the development of robust objects for use in Taylor ED, and continued to sell, consult, and train in the new software.

In 2000, as F&H Holland was being acquired, F&H Simulations took the opportunity to become independent. Dr. Eamonn Lavery and Anthony Johnson joined to oversee product architecture and begin development of a new 3D object-oriented simulation software called FlexSim®. F&H Simulations, Inc. changed its name to FlexSim Software

Products, Inc. FlexSim® 1.0 was released in February 2003, boasting a state-of-the-art simulation engine, a 3D modeling environment, and seamless integration with C++—all firsts in discrete event simulation.
In the years since, FlexSim® has become the standard in discrete event simulation software. With a vast array of tools covering manufacturing, material handling, healthcare, logistics, and supply chain, FlexSim® is the preferred choice of a fast-moving global marketplace that needs quick and accurate answers. FlexSim—Problem Solved

2. LITERATURE SURVEY

1. **Ireneusz Kaczmar et al**. Have done the project entitled Optimization of Flow Shop Scheduling Problem: Simulation System vs. Evolutive Solver. In the Industry 4.0 era the optimisation of production processes become more and more important. A wide range of tools are used to improve the performance of production processes and related operations of the supply chain including purchasing, distribution and inverse processes. These tools have a great impact on the results of design and operation of production processes both technology and logistics point of view. Within the frame of this article, the authors are demonstrating the optimisation potentials of simulation tools and heuristic solvers (optimisers) through the problem of the well-knows permutation flow shop scheduling. They are describing the models and methods used in the case of FlexSim simulation systems and the heuristic solver option of Excel Solver. As the numerical results show, both the simulation model and the heuristic optimisation approach lead to a quasi-optimal solution.
2. **Marek Krynke,** Has done the project entitled, Personnel Management on the Production Line Using the FlexSim Simulation Environment presents the problem of personnel allocation to the production line. The basic stages of developing a simulation model of this process are discussed, including all necessary information and inputs. The results shows impact of the selected simulation scenarios to the workload level of the staff and the duration of the production process. In this concept, to solve the problem a simulation model of the production process was built. A new generation of 3D FlexSim simulation environment with an integrated OptQuest optimization module was used.
3. **Sungbum Jun et al,** Have done the project entitled, Scheduling of autonomous mobile robots with conflict-free routes utilising contextual-bandit-based local search. As autonomous robot and sensor technologies have advanced, utilisation of autonomous mobile robots (AMRs) in material handling has grown quickly, owing especially to their scalability and versatility compared with automated guided vehicles (AGVs). In order to take full advantage of AMRs, in this paper, we address an AMR scheduling and routing problem by dividing the entire problem into three sub-problems: path finding, vehicle routing, and conflict resolution. We first discuss the previous literature on characteristics of each sub-problem. We then present a comprehensive framework for minimising total tardiness of transportation requests with consideration of conflicts between routes. First, the shortest paths between all locations are calculated with A*. Based on the shortest paths, for vehicle routing, we propose a new local search algorithm called COntextual-Bandit-based Adaptive Local search with Tree-based regression (COBALT), which utilises the contextual bandit to select the best operator in consideration of contexts. After routing of AMRs, an agent-based model with states and protocols resolves collisions and deadlocks in a decentralised way. The results indicate that the proposed framework can improve the performance of AMR scheduling for conflict-free routes and that, especially for vehicle routing, COBALT outperforms the other algorithms in terms of average total tardiness.

3. PROBLEM STATEMENT AND SOLUTION

The problem statement has given in the table format

Sequence of Material Flow			
S.No.	**Item Type 1**	**Item Type 2**	**Item Type 3**
1	Source 1	Source 2	Source 3
2	Queue 1 + Operator	Queue 1 + Operator	Queue 1 + Operator

3	Processor 1 + Operator	Processor 2 + Operator	Processor 3 + Operator
4	Queue 2 + Transporter 1	Queue 2 + Transporter 1	Queue 2 + Transporter 1
5	Rack 2	Rack 3	Rack 1
6	Red	Green	Blue

S.No.	Resources	Parameters
1	Source	Input is Unlimited: Product arrives at the interval of 180 s
2	Processor 1	Quantity: 1 at a time and Process time: 600 sec
3	Processor 2	Quantity: 1 at a time and Process time: 600 sec
4	Processor 3	Quantity: 1 at a time and Process time: 600 sec
5	Queue 1	Capacity 10000
6	Queue 2	Capacity 10000
7	Dispatcher 1	Sort by Task Sequence Priority
8	Operator	Quantity: 3
9	Transporter	Quantity: 1
10	Rack 1	Item type 3 form Queue output
11	Rack 2	Item type 1 form Queue output
12	Rack 3	Item type 2 form Queue output

With the given above problem statement data, the below layout has drawn

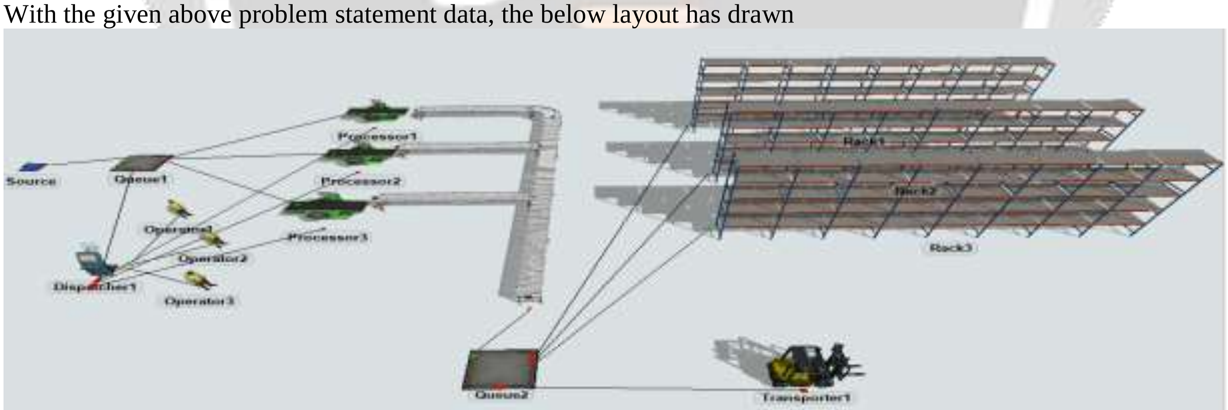


Figure 4.1: Initial layout

Steps are followed to build above layout

Source: Inter-arrival time need to set for 180 seconds as per the given problem, Triggers> on creation> set label and colour – to get different colours of components. Duniform (1,3) to get three colour objects from the source.

Queue1: Maximum quantity has given 10000 as per the problem statement. Output> send to port> by expression. Select use transport> current.centerObjects[1] > Dispatcher 1. Three coloured objects will be send to the machines with the help of dispatcher, dispatcher will utilize the available operator to send the objects to the respective machines. One colour to one machine.

Processor: Processing time has given 600 seconds as per the given data. This is same for Processor 1, 2, 3.

Queue 2: Maximum quantity has given 10000 as per the problem statement. Output> send to port> Using Global Lookup Table (Mini project table).

As per the above Global table the queue will send the same coloured components to one rack. It means three coloured components will be sent to 3 different rack by using Transporter.

The processing is set for 6 days with three shifts per day.

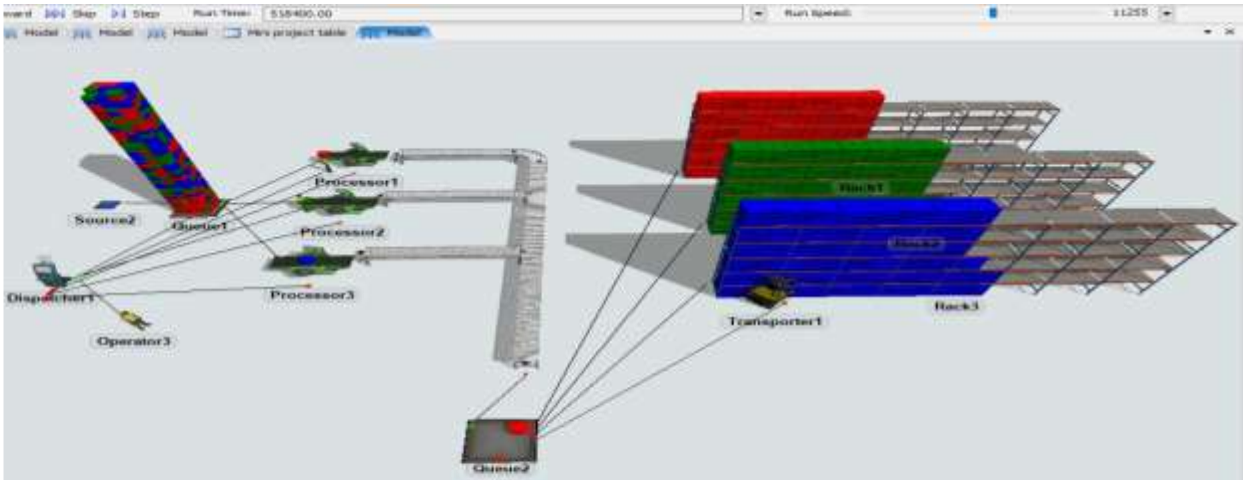
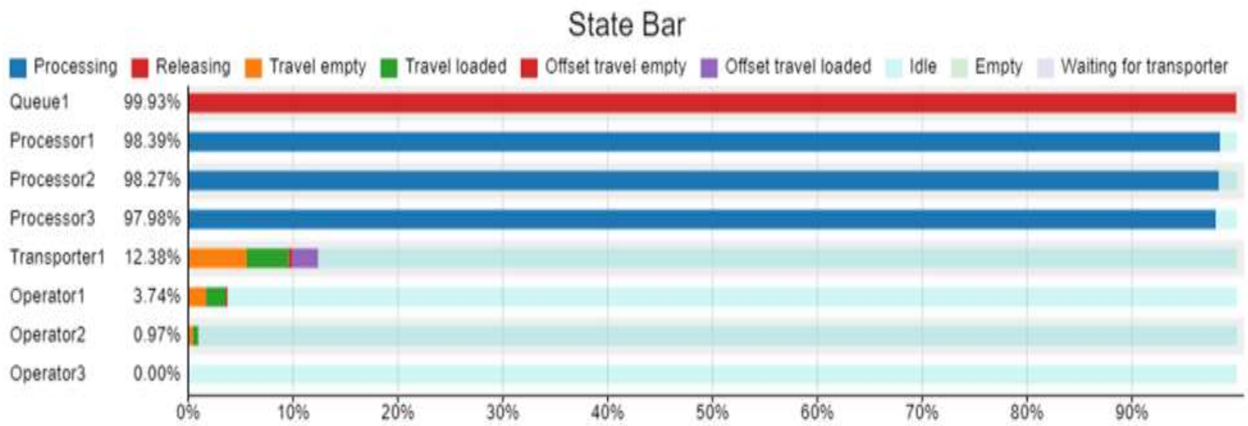


Figure 4.2: Initial layout after 6 days with three shifts per day

The results are as follows after 6 days with three shifts per day

S. No.	Component	Amount of Processing	Amount of Ideal	Amount of Releasing
1	Queue 1	-	0.07%	99.93 %
2	Processor 1	98.39%	1.16%	-
3	Processor 2	98.27%	1.73%	-
4	Processor 3	97.98%	2.02%	-
5	Operator 1	3.74%	98.26%	-
6	Operator 2	0.97%	99.03%	-
7	Operator 3	0%	100%	-
8	Transporter 1	12.38%	87.62%	-



It is observed that, more amount of components are still pending to send processors. Input to Queue 1 is 2879, output from Queue 1 is 2548, which means 331 components are still waiting in Queue 1. There is a big jam at Queue 1, this is called Bottle neck problem. Bottle neck problems should be eliminated in the layout by adding buffer storages at processors or balance the line.
Only 2 operators are working, 3 operator is 100% ideal. So, operator 3 can be eliminated from the layout.

Optimized layout

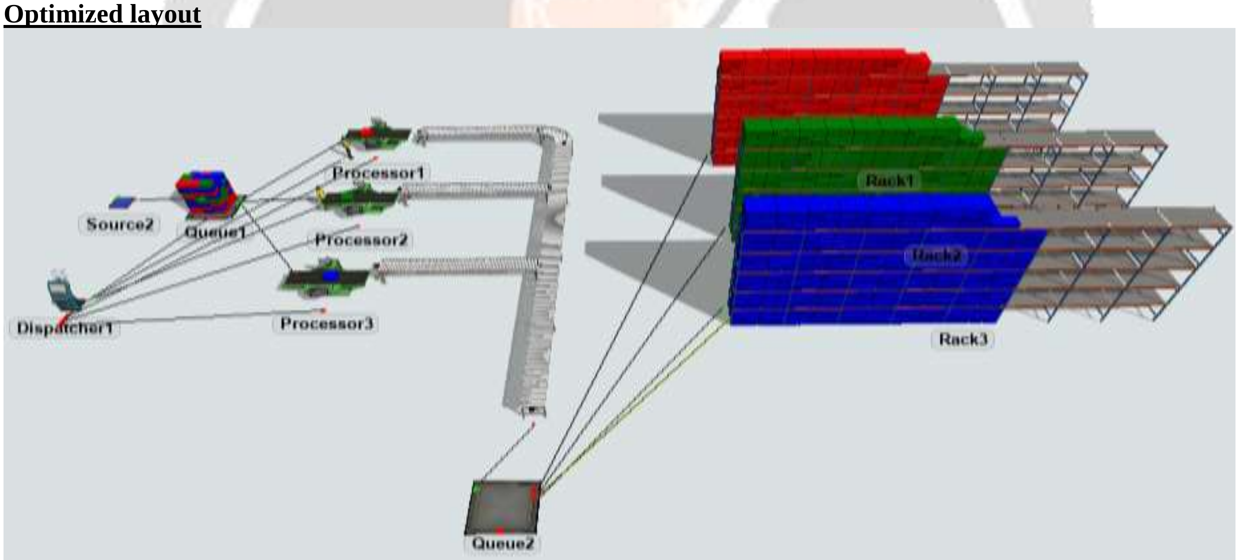


Figure 4.3: optimized layout after 6 days with three shifts per day

The layout is optimized by utilizing high capacity machines/ increase the capacity of existing machine to reduce processing time from 600 seconds to 540 seconds, this has given good results, and reduced bottle beck problems at Queue 1. The Queue 1 has produced 2879, output from Queue 1 is 2510. Only 69 components are available in Queue 1 in 6 days (per day 3 three shifts)

The optimized results are as follows after 6 days with three shifts per day

S. No.	Component	Amount of Processing	Amount of Ideal	Amount of Releasing
1	Queue 1	-	0.07%	99.93 %

2	Processor 1	98.06%	1.94%	-
3	Processor 2	97.44%	2.56%	-
4	Processor 3	97.05%	2.95%	-
5	Operator 1	3.83%	96.17%	-
6	Operator 2	1.34%	98.66%	-
7	Transporter 1	13.82%	86.18%	-

4. CONCLUSIONS

- The layout is optimized as per the requirement
- Routing and scheduling has been done properly to reduce bottleneck problems at Queue 1
- Operator 3 has been eliminated, i.e cost is reduced
- 80% improvement is observed in the new optimized layout. The bottle neck problem is bring to 20%.

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