Developing an Information System for Scheduling and Sequencing in Manufacturing Environment
(PBI presentation)

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Outline

➢ Concepts of Scheduling and Sequencing.

➢ Classification of Scheduling Problems.

➢ Existing Approach for Scheduling in Manufacturing.

➢ Our Methodology.

➢ Types of Scheduling Problems.

➢ Complexity of Scheduling Problems.

➢ Optimization Methods Used.

➢ Information System Design.

➢ Applications Employed.

➢ Conclusions.

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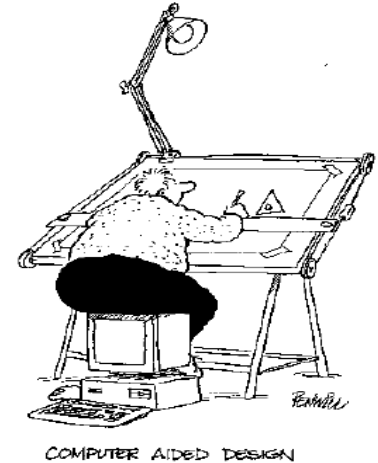
Motivation

➢ Why is this stuff interesting?

➢ It's challenging

Mainly due to the resource allocation phase

➢ It's a real world problem

It's important to test solvers on real problems

➢ We considered many problem variants

Different objective function

Deterministic vs Stochastic

➢ Generating the schedule and a sequence is quite challenging

Introduction

➢ **Scheduling** is the process of deciding how to commit resources between a variety of possible tasks.

➢ **Sequencing** refers to determining the order in which jobs or tasks are processed.

M3	J3	▬	J1		▬
M2	J2		J3		▬
M1	J1		J2		▬

Application Areas

Manufacturing	Services	Vehicle Routing	Info. Proc. & Comm.

Manufacturing
- ☐ Single Machine
- ☐ Parallel Machine
- ☐ Open-shop
- ☐ Flow-shop
- ☐ Job-shop

Services
- ☐ Reservations
- ☐ University
- ☐ Staff Scheduling
- ☐ Crew Scheduling
- ☐ Hospitals
- ☐ Transportation

Vehicle Routing
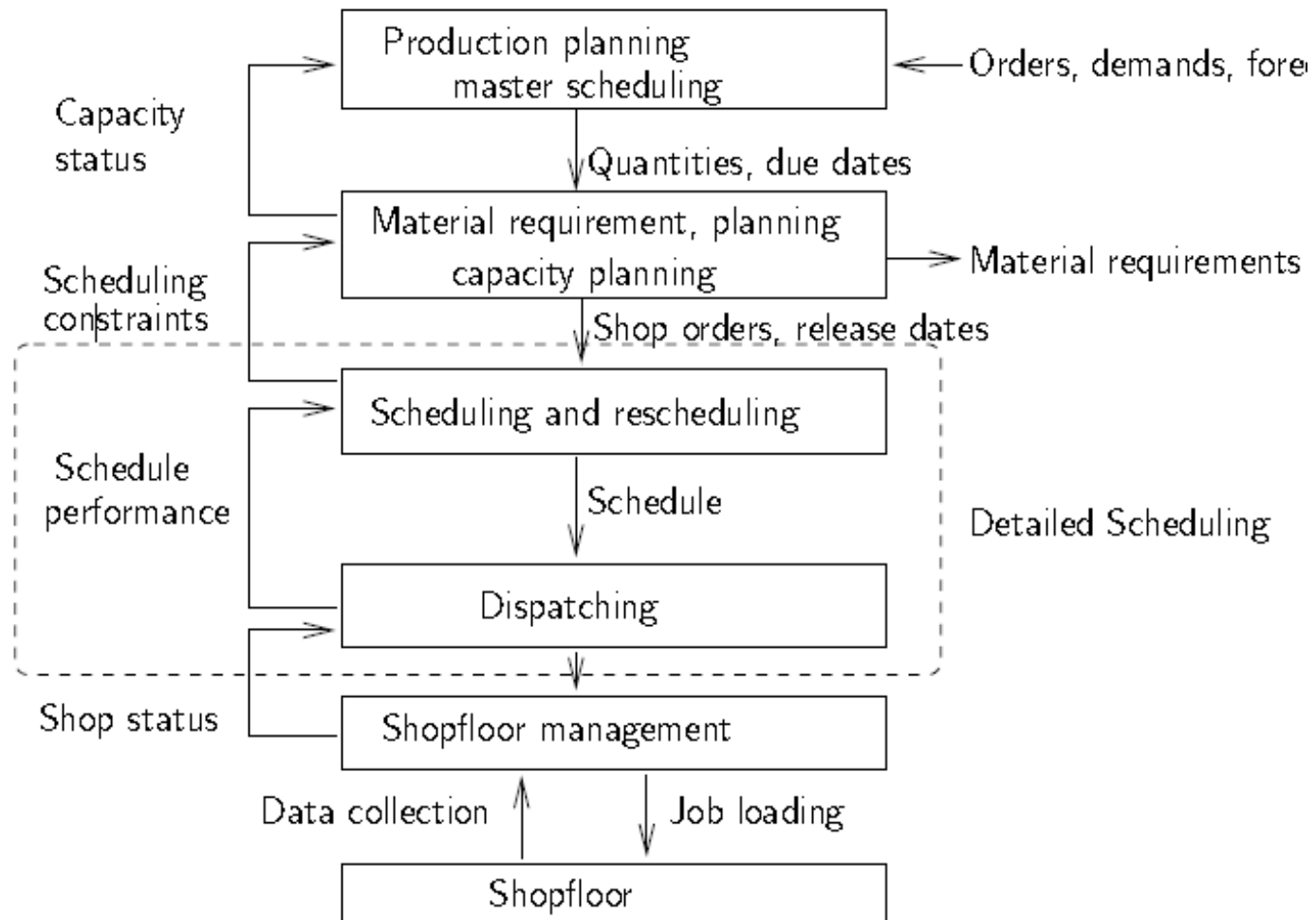- ☐ Vehicle Routing
- ☐ TSP
- ☐ Roastering

Info. Proc. & Comm.
- ☐ CPU's
- ☐ Series Computing
- ☐ Parallel Computing
- ☐ Call Centers

Scheduling in Manufacturing
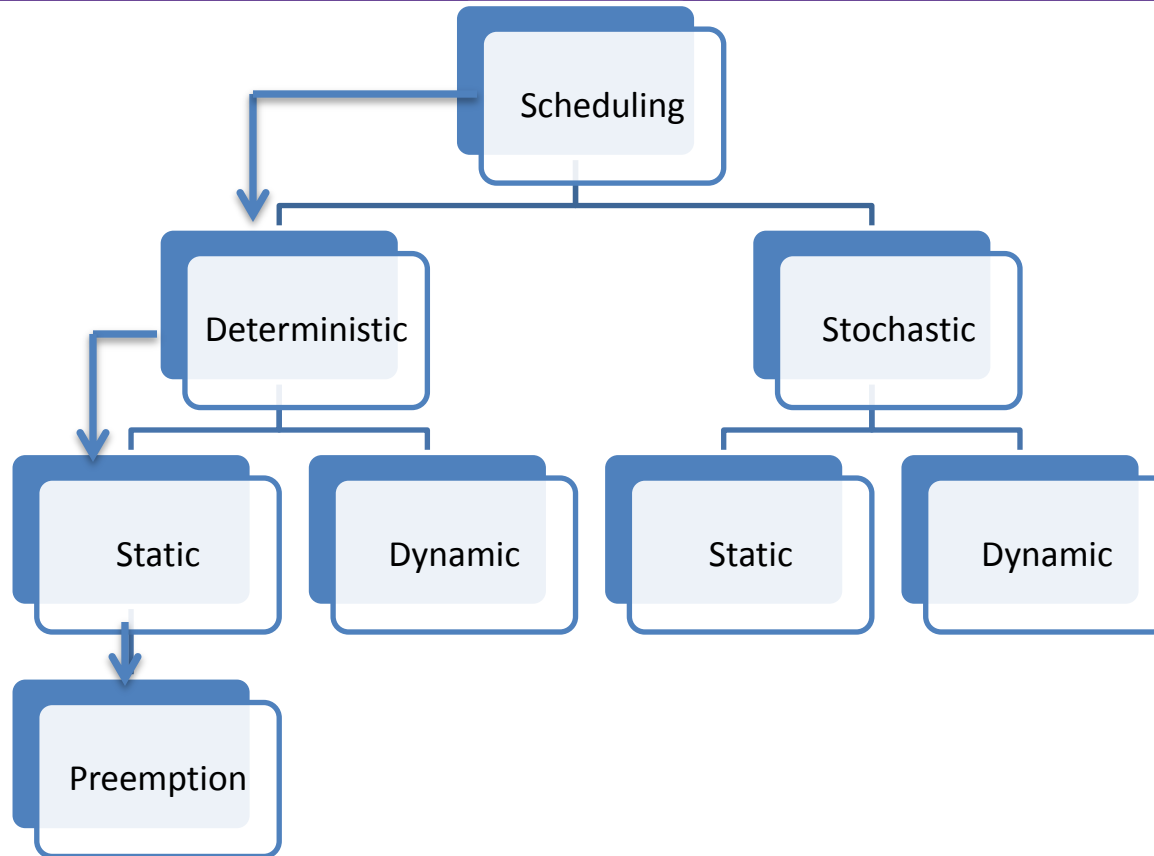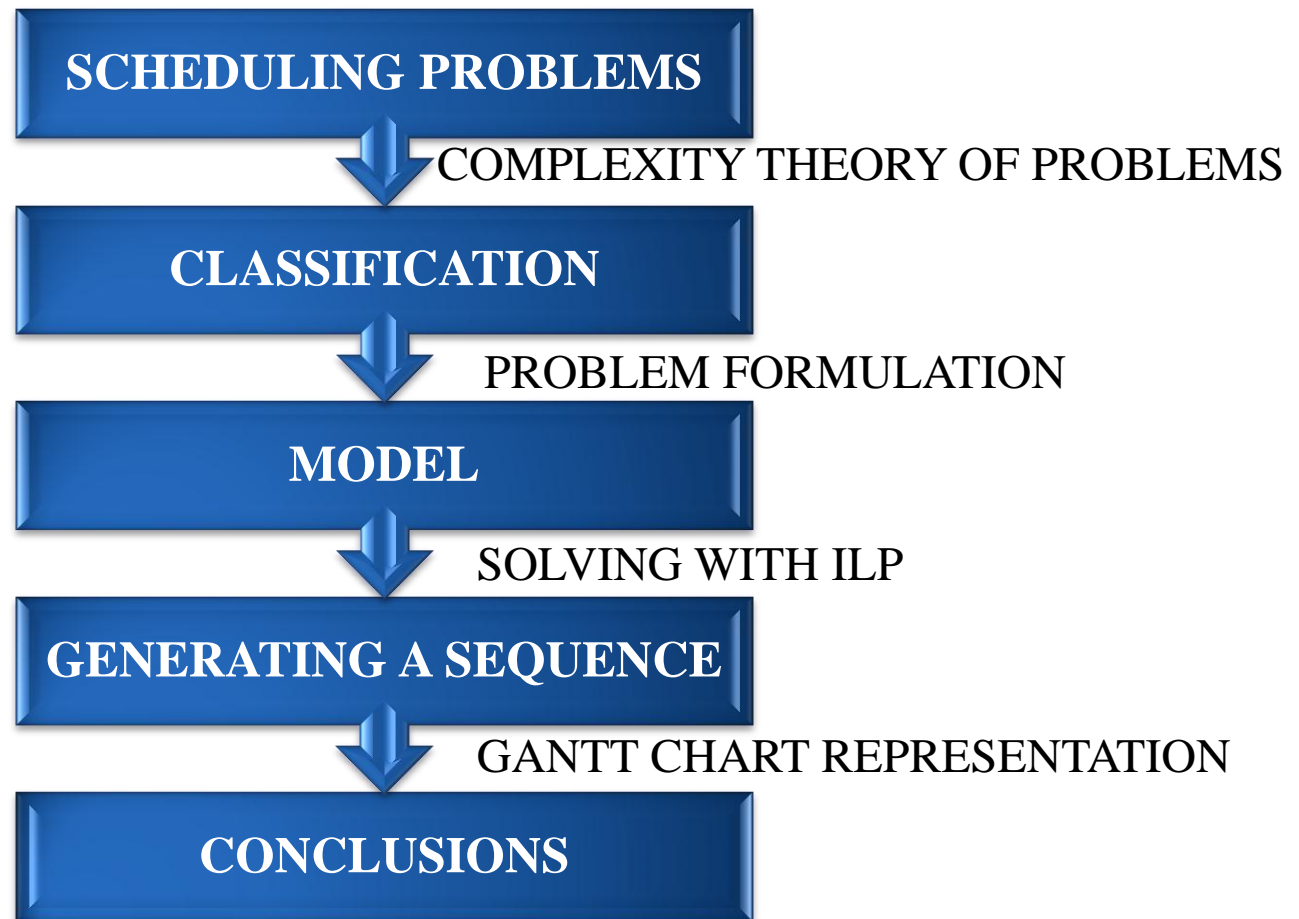
Scheduling Hierarchy In Manufacturing

Our Approach

SCHEDULING PROBLEMS

COMPLEXITY THEORY OF PROBLEMS

CLASSIFICATION

PROBLEM FORMULATION

MODEL

SOLVING WITH ILP

GENERATING A SEQUENCE

GANTT CHART REPRESENTATION

CONCLUSIONS

Notations

➢ We used three field classification α|β|γ to specify class of scheduling problems, where

α specifies the machine environment ,

β specifies the job characteristics and

γ denotes the optimality criterion.

➢ For example $1|\text{prec}|C_{max}$, $j|\text{pmtn}|C_{max}$

Types of Scheduling Problems

- ➢ Single machine scheduling problems

- ➢ Parallel machine scheduling problems

- ➢ Open shop scheduling problems

- ➢ Job shop scheduling problems

Single Machine Scheduling

➢ There are n single-operation jobs simultaneously available for processing.

➢ Machines can process at most one job at a time.

➢ Machines are continuously available.

➢ Machines are never kept idle while work is waiting.

➢ Once an operation begins, it proceeds without interruption.

J2 → J1 → J5 → J4 → J3

Single machine sequencing for 5 jobs

Parallel Machine Scheduling

➢ There are n machines which are placed in parallel.

➢ In parallel machine jobs can be processed without preemption and with preemption.

➢ Preempting a job means we can interrupt a job/operation on any machine and resumed later.

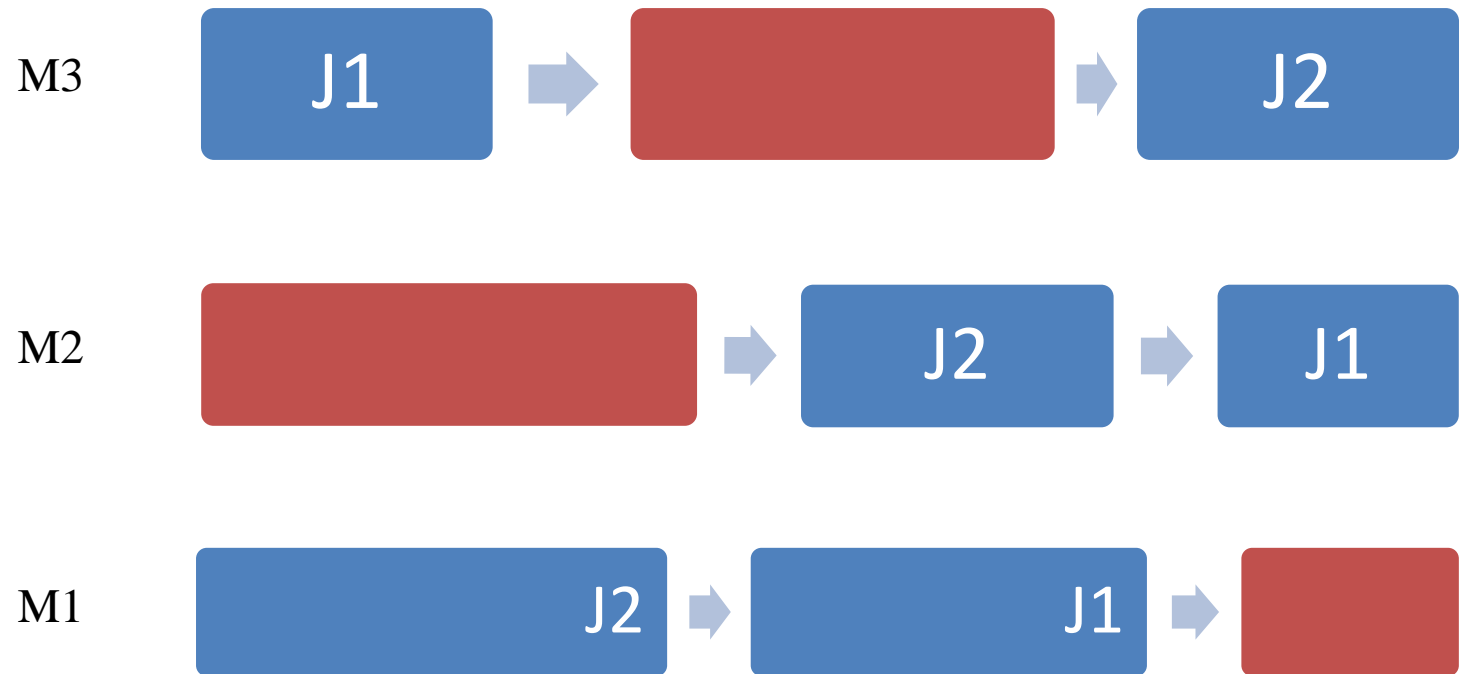➢ Non-preemption means we cannot interrupt a operation until the operation is completed.

Open Shop Scheduling

➢ A set of n jobs and m machines.

➢ An open-shop problem is without any precedence relations between the operations.

➢ The scheduler is allowed to determine the route for each job, and different jobs may have different routes.

Job Shop Scheduling
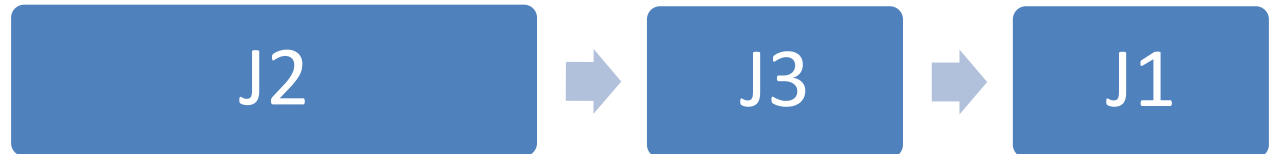
➢ A fixed set of n jobs.

➢ Each job consists of a chain of operations.

➢ A fixed set of m machines that each operation uses.

➢ Each machine can handle at most one operation at a time.

➢ Aim is to find a schedule that has minimal length.

Complexity

➢ The complexity of an algorithm is its running time in terms of the input parameters (e.g., number of jobs and number of machines)

➢ Big-Oh notation, e.g., $O(n^2m)$ for job-shop.

➢ 3-jobs,3 machines will have 3! =6 permutations

➢ 5-jobs,5 machines will have 5!= 120 permutations

➢ 10-jobs,10 machines will have 10!= 3628800 permutations.

| n	n*n	2^n	nlogn
1	1	2	0
2	4	4	2
4	16	16	8
8	64	256	24
16	256	65536	64

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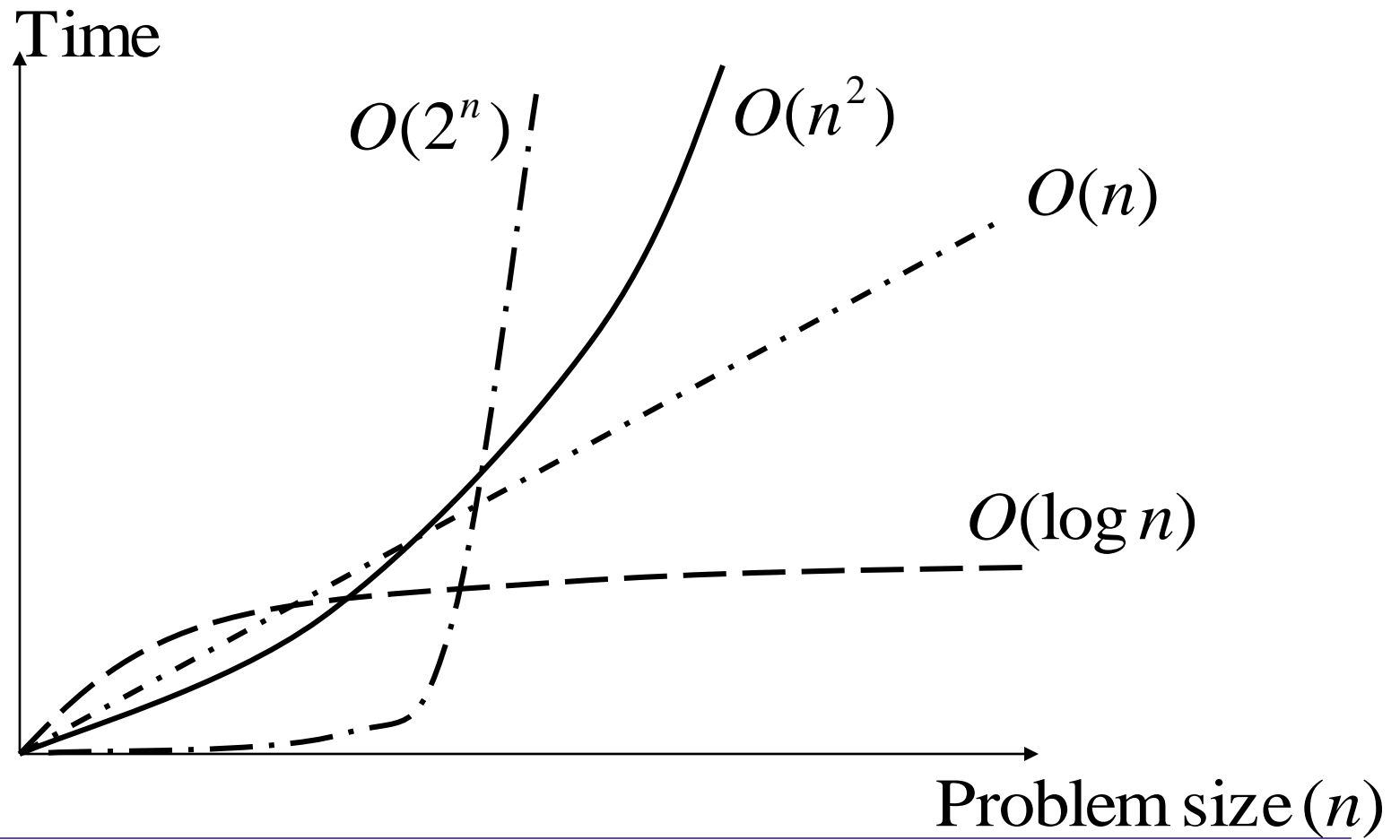
NP-Hard

- In order to define NP-hard at first some preliminary definitions have to be given.

- Decision Problem- Any problem for which the answer is either 0 or1

- Optimization Problem- Any problem that involves the identification of an optimal(either minimum or maximum) value of a given function is known as a optimization problems. Most scheduling problems belong to the class of optimization problems.

- P problems -P is a set of all decision problems solvable by deterministic algorithm in polynomial time.

➢ NP is the set of all decision problems solvable by non deterministic algorithm in polynomial time.
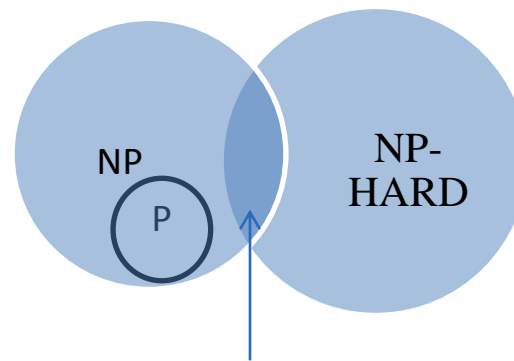
NP-COMPLETE

Job-Shop problem is NP Hard.

Optimization Methods Used

➤ Mathematical approach

ILP(Integer Linear Programming)

➤ Heuristic

Branch and Bound

➤ Dispatching Rules

SPT(Shortest Processing Time)

EDD(Earliest Due Date)

LPT(Longest Processing Time)

➢ ILP(Integer Linear Programming)

Linear programming is a mathematical method for determining a way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model for some list of requirements represented as linear relationships.

➢ For practical purposes, we can think of the linearity requirement as consisting of three features:

Objective Function

Decision Variables

Constraints

➢ Branch and Bound

  Branch and Bound is a general algorithm for finding optimal solutions of various optimization problems, especially in discrete and combinatorial optimization.

  combinatorial optimization means finding an optimal solution from a finite set of solutions (maximize/minimize objective subject to constraints).

➢ For combinatorial optimization problems B-B gives optimum results for small problem size.

➢ SPT(Shortest Processing Time)

In this rule we find a job which has shortest processing time and we process that job first and so on.

➢ EDD(Earliest Due Date)

In this rule we find a job which has shortest due date and we process that job first and so on.

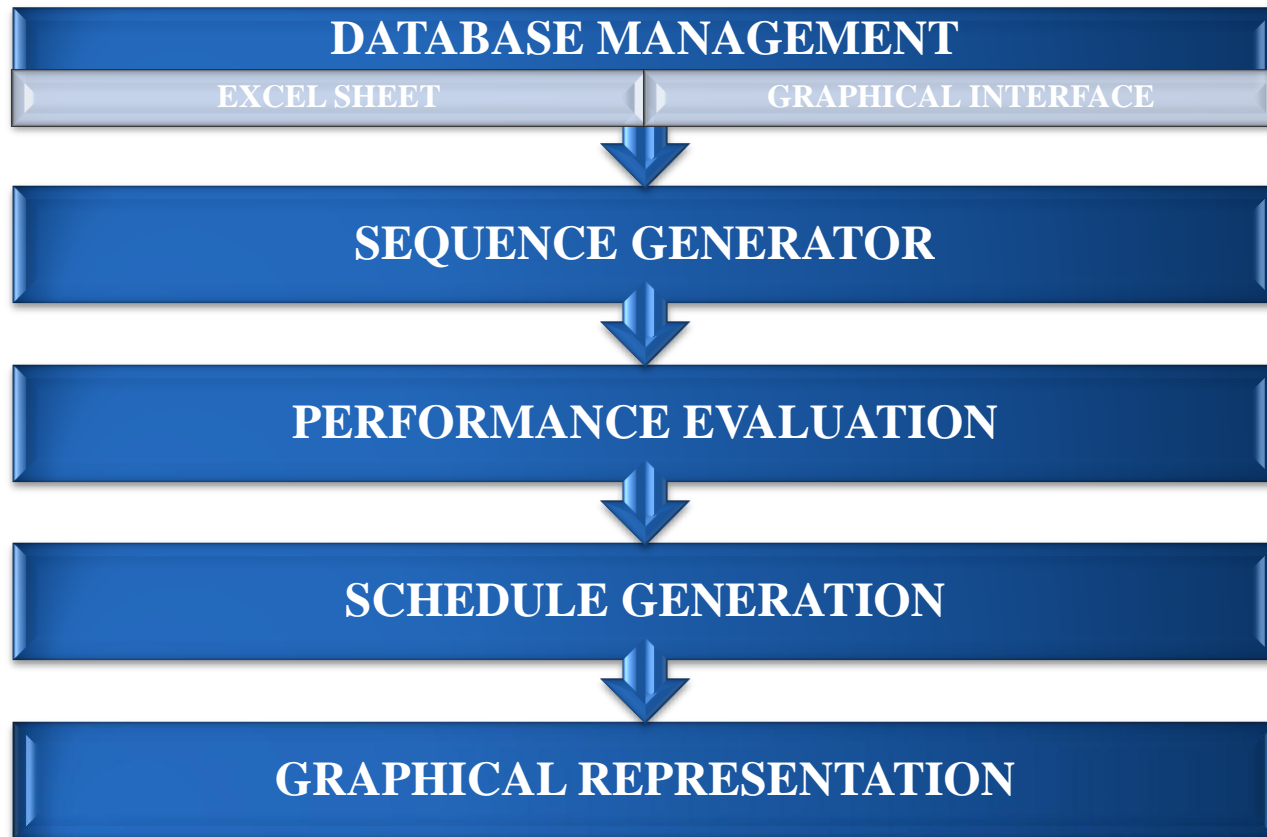➢ LPT(Longest Processing Time)

In this rule we find a job which has longest processing time and we process that job and so on.

Information System Design

ORDERING MASTER FILE   SHOP FLOOR DATA COLLECTION

DATABASE MANAGEMENT

EXCEL SHEET   GRAPHICAL INTERFACE

SEQUENCE GENERATOR

PERFORMANCE EVALUATION

SCHEDULE GENERATION

GRAPHICAL REPRESENTATION

Choosing Application

➢ We have employed three applications in this research work to generate the optimum schedule for Sequencing and Scheduling in Manufacturing. In selecting the application following criteria were considered:

Affordable Application-Low cost or Open Source.

Automation Ability-Supports a Programming Language.

Able to Import/Export common Files-Database Connectivity

Application Used

➢ Lingo Optimization Tool was used. Trial version of Lingo is available with no cost. Lingo 10.0 supports Visual basic for application (VBA) language, which facilitates automation in importing/exporting data.

➢ Another application chosen for this research is Lekin (freeware), which is a manufacturing environment scheduler. Allows us to generate the sequence.

➢ The third application an Information System which is based on Microsoft Excel. Obviously MS-Excel support automation capabilities with VBA, which allows us to import/export various types of files.

Conclusion

➤ Briefly classifying the Scheduling and Sequencing Problems.

➤ Proved Integrity of ILP model for Basic Scheduling problems in manufacturing and checking the Robustness by implementing over Lingo using VBA Programming for small size problems.

➤ The following System can be linked to MRP System for Production Scheduling.

➤ Following Model works fine for small size problems with Heuristic Approach but time complexity increases for larger size problems.

➤ To solve the larger size problems Meta-heuristic can be applied to get the optimum results.

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