PRO5802 - Programação de Produção Intermitente (2021)

Aula 5 – Teoria de Flowshop

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Flow Shop

General Shop Scheduling:

- $J = \{1, \ldots, N\}$ set of jobs; $M = \{1, 2, \ldots, m\}$ set of machines
- $J_j = \{O_{ij} \mid i = 1, \ldots, n_j\}$ set of operations for each job
- p_{ij} processing times of operations O_{ij}
- $\mu_{ij} \subseteq M$ machine eligibilities for each operation
- precedence constraints among the operations
- one job processed per machine at a time,
  one machine processing each job at a time
- C_j completion time of job j

➡ Find feasible schedule that minimize some regular function of C_j

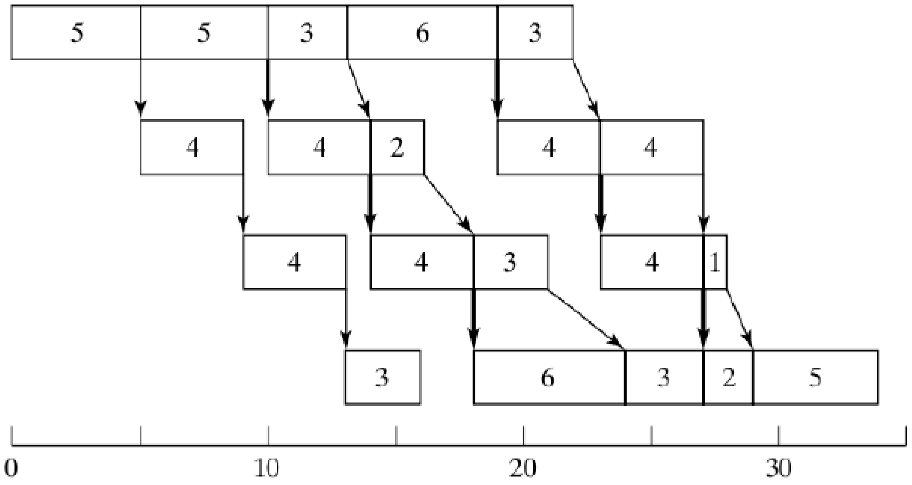
Flow Shop Scheduling:

- $\mu_{ij} = l$, $l = 1, 2, \ldots, m$
- precedence constraints: $O_{ij} \rightarrow O_{i+1,j}$, $i = 1, 2, \ldots, n$ for all jobs

Example

$jobs$	j_1	j_2	j_3	j_4	j_5
p_{1,j_k}	5	5	3	6	3
p_{2,j_k}	4	4	2	4	4
p_{3,j_k}	4	4	3	4	1
p_{4,j_k}	3	6	3	2	5

Gantt chart



schedule representation

$\pi_1, \pi_2, \pi_3, \pi_4$:

$\pi_1 : O_{11}, O_{12}, O_{13}, O_{14}$

$\pi_2 : O_{21}, O_{22}, O_{23}, O_{24}$

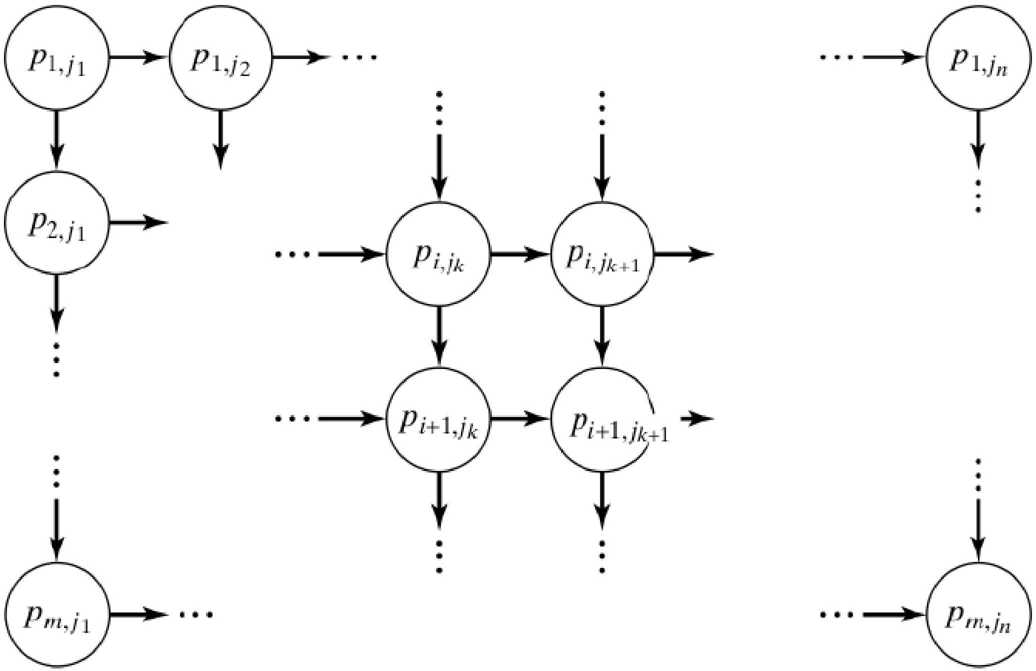
$\pi_3 : O_{31}, O_{32}, O_{33}, O_{34}$

$\pi_4 : O_{41}, O_{42}, O_{43}, O_{44}$

- we assume unlimited buffer
- if same job sequence on each machine ➨ permutation flow shop

Directed Graph Representation

Given a sequence: operation-on-node network,
jobs on columns, and machines on rows



FS with Unlimited Intermediate Storage

Recursion for C_{max}

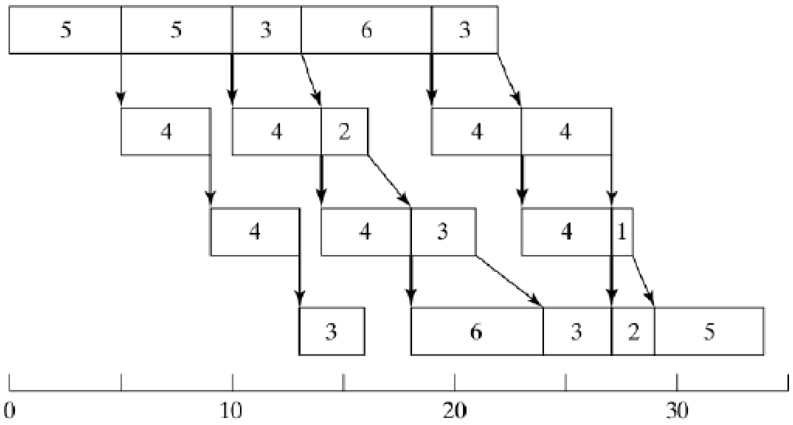
$$
\begin{aligned}
C_{i,\pi(1)} &= \sum_{l=1}^{i} p_{l,\pi(1)} \\
C_{1,\pi(j)} &= \sum_{l=1}^{j} p_{l,\pi(l)} \\
C_{i,\pi(j)} &= \max\{C_{i-1,\pi(j)}, C_{i,\pi(j-1)}\} + p_{i,\pi(j)}
\end{aligned}
$$

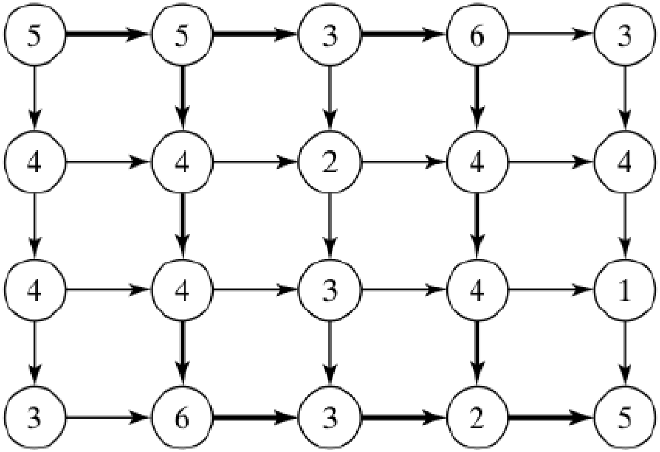
Example

$jobs$	j_1	j_2	j_3	j_4	j_5
p_{1,j_k}	5	5	3	6	3
p_{2,j_k}	4	4	2	4	4
p_{3,j_k}	4	4	3	4	1
p_{4,j_k}	3	6	3	2	5

$C_{max} = 34$

corresponds to longest path





FS with Limited Intermediate Storage

Recursion for C_{max}

$$C_{i,\pi(1)} = \sum_{l=1}^{i} p_{l,\pi(1)}$$

$$C_{1,\pi(j)} = \sum_{l=1}^{j} p_{l,\pi(l)}$$

$$C_{i,\pi(j)} = \max\{C_{i-1,\pi(j)} + p_{i,\pi(j)}, C_{i+1,\pi(j-1)}\}$$

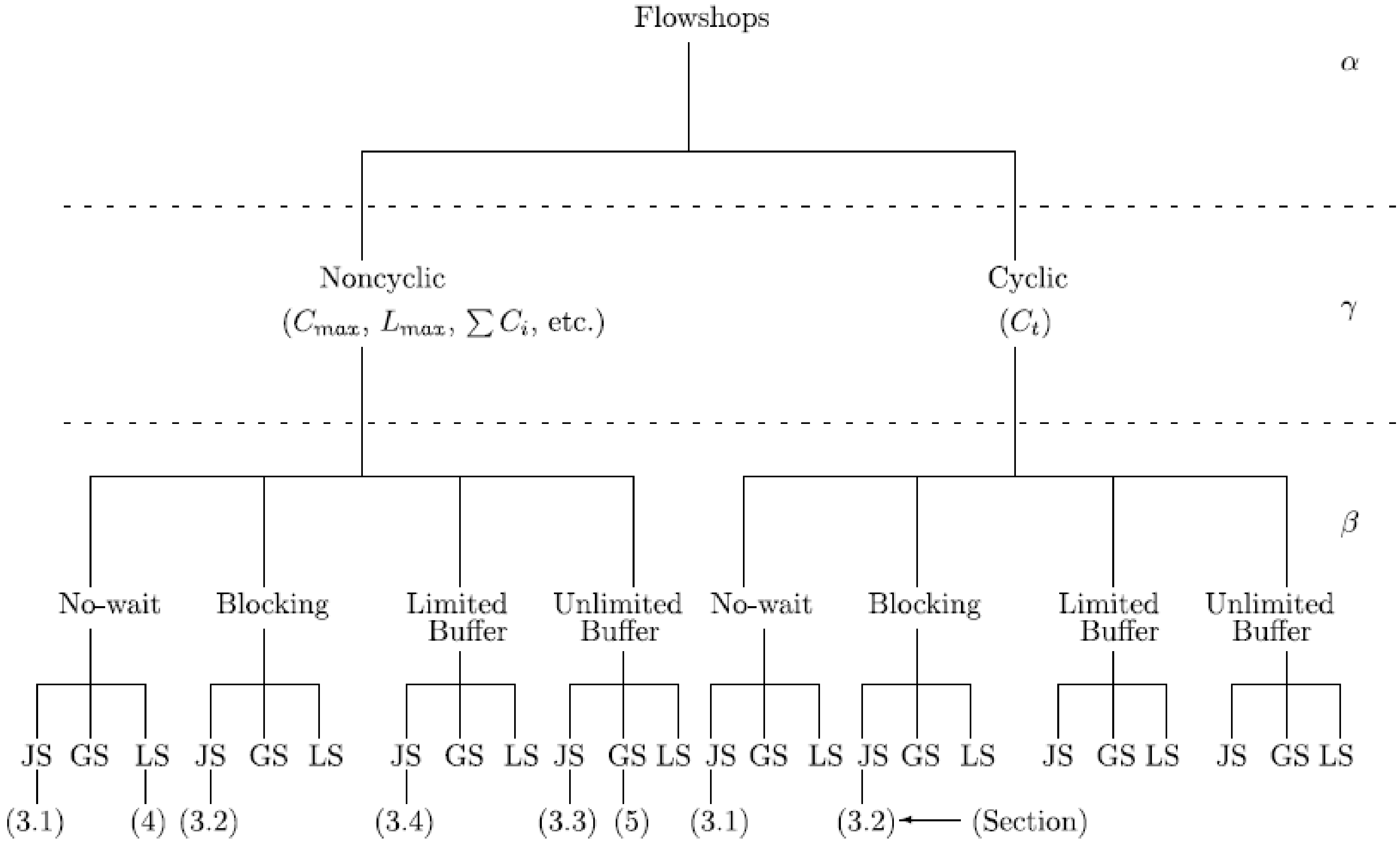
$$C_{m,\pi(j)} = C_{m-1,\pi(j)} + p_{m,\pi(j)}$$

Construction Heuristics (1)

$Fm \mid prmu \mid C_{max}$

Slope heuristic

- schedule in decreasing order of $A_j = -\sum_{i=1}^{m}(m - (2i - 1))p_{ij}$


Flowshops
α
Noncyclic
(C_{max}, L_{max}, $\sum C_i$, etc.)
Cyclic
(C_t)
γ
β
No-wait
Blocking
Limited Buffer
Unlimited Buffer
No-wait
Blocking
Limited Buffer
Unlimited Buffer
JS GS LS JS GS LS JS GS LS JS GS LS JS GS LS JS GS LS JS GS LS JS GS LS
(3.1) (4) (3.2) (3.4) (3.3) (5) (3.1) (3.2)
(Section)

Próxima aula

Retomamos as 10:05

- Discussão artigo:

A review of TSP based approaches for flowshop scheduling

Tarefa:

Cada dupla apresentar uma das **2.1. Classification of flowshops** indicando:

- Explicação do tipo
- Características
- Exemplo numérico (com o Gantt)
- Caso real de uso