A New Heuristic for the Multi Model Assembly Line Balancing Problem

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Outline

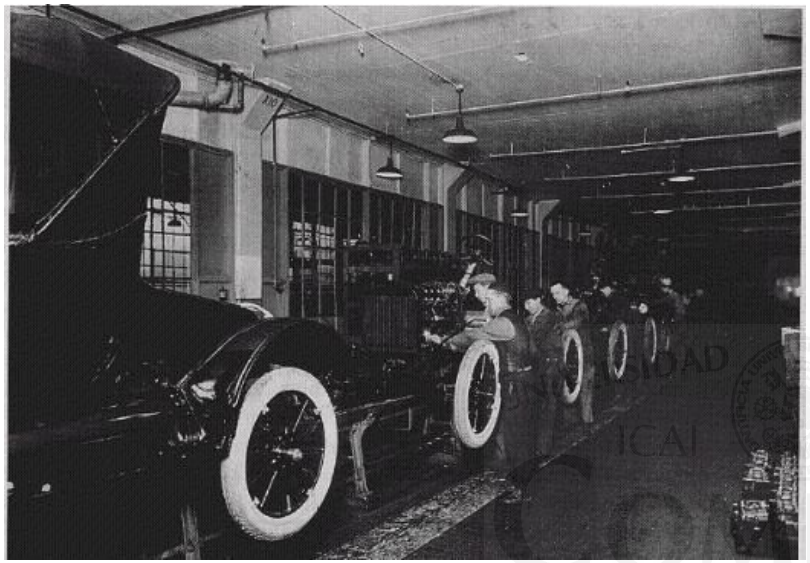
- Introduction
- Balancing Problem
- Assembly Management
- Model Description
- Solving Algorithm
- Results

Introduction

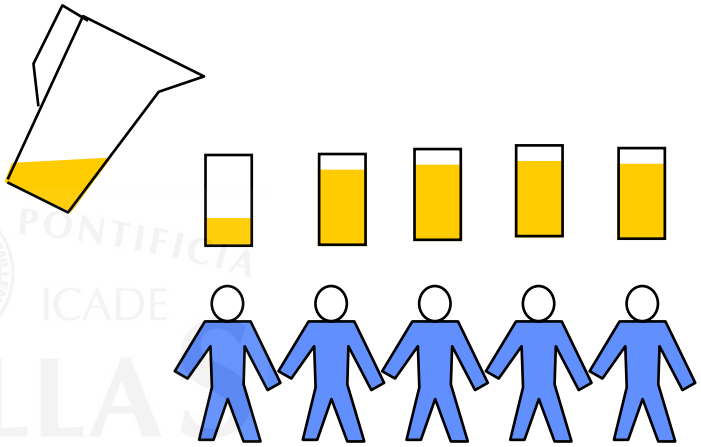
Small Generator Assembly Line

Assembly Line Dimension

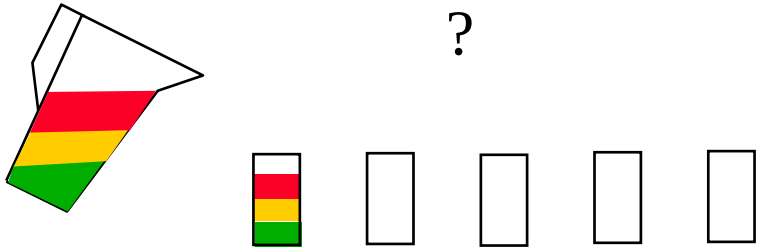
Balancing problem



"Ford idea": Repetitive **homogeneity**



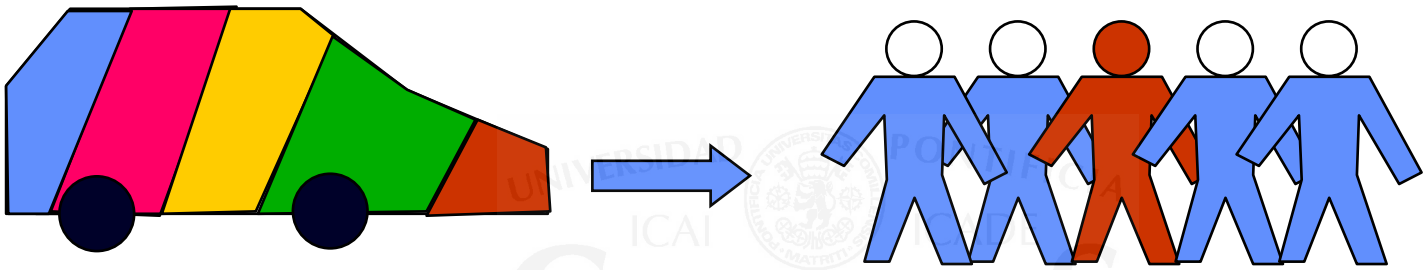
Customization: **Heterogeneity**



Assembly Management (i)

- **Mixed Model Production**

Sequencing vehicles to avoid unfeasible overloads on workplaces



- **Multi Model Production: Mair(98)**

Model #1
Batch #1

Model #2
Batch #2

Model #3
Batch #3

Sequencing batches of vehicles to cope with customer demand

Assembly Management (ii)

Mixed Model Production

Balancing based on Mixed Task i Time

$$\text{Mixed Task i Time: } \frac{\sum_m n_m \times d_{i,m}}{\sum_m n_m}$$

Multi Model Production

Balancing based on:

- Model m Task i Time : t_{im}
- At each model identified by
  - Driving side
  - Type of engine
  - Chasis,…

Assembly Management (iii)

Mixed Model Production

Advantages:

FASTER	customer delivery
FASTER	balancing solution

Disadvantages:

MORE	production incidents
LOWER	workplace productivity

Multi Model Production

Disadvantages:

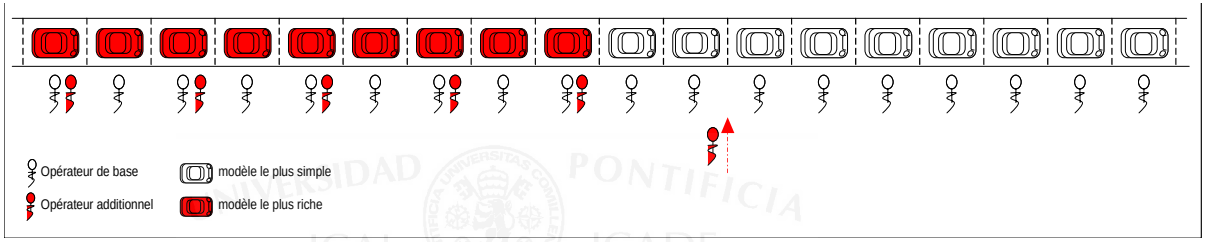
SLOWER	customer delivery
SLOWER	balancing solution

Advantages:

LESS	production incidents
UPPER	workplace productivity

Assembly Management (iv)

Multi Model Production



- Type of models: basic vs customised
- Sizes of batches per model
- Sequence of batches
- Workplaces: permanent vs temporary
- Balancing per model

Model description (I)

DATA

T tasks
P workplaces
M models
H altimetries
Q vehicles zones

$d_{t,m}$ duration task *t* on model *m*
h_t altimetry of task *t*
b_t machine require to perform task *t*
$Prec_t$ previous tasks to task *t*
IM_p machines on workplace *p*
IQ_p vehicle zones of workplace *p*
ct cycle time

Model description (II)

VARIABLES

$BP_{t,p}$ Indicator task *t* assigned to workplace *p* {0/1}

$BH_{p,h}$ Indicator of altimetry *h* of task *t* {0/1}

$BPM_{p,m}$ Indicator of workplace *p* assigned to model *m* {0/1}

P_t Workplace assigned to task *t* {integer}

Model description (III)

OBJECTIVE FUNCTION

$$Min \sum_{p,m} \alpha_m \cdot BPM_{p,m}$$

Minimization of effective workplaces
to cope with multi model production

α_m : m-Model quota of production

$\sum_{p} BPM_{p,m}$: number of workplaces assigned to model m

Model description (IV)

CONSTRAINTS

$$\sum_t BP_{t,p} \cdot d_{t,m} \leq ct \cdot BPM_{p,m} \quad \forall p,m$$

$$\sum_p BP_{t,p} = 1 \quad \forall t$$

Limit of workplace overload per model

$$P_{tt} \leq P_t \quad \forall tt \in Prec_t, t \in Tasks$$

Task Nonanticipaty

Model description (IV)

CONSTRAINTS (Cont.)

$$P_t \neq p \quad \forall p,t \in Tasks \,|\, m_t \notin IM_p$$

$$P_t \neq p \quad \forall p,t \in Tasks \,|\, q_t \notin IQ_p$$

Machine available at each workplace
Vehicle position at each workplace

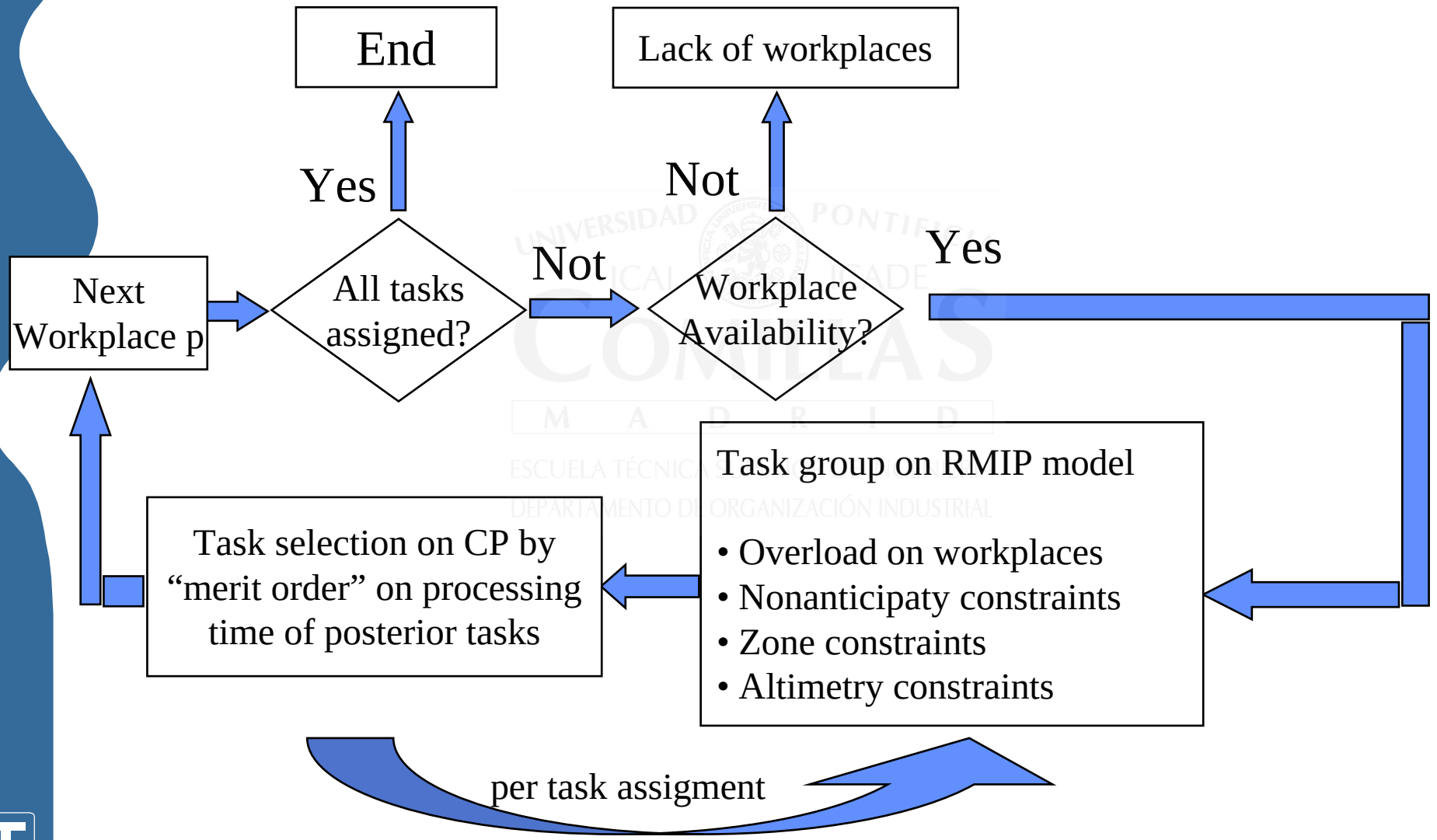
$$\sum_{t \in Tasks \,|\, h_t = h} BP_{t,p} \leq BH_{p,h} \cdot card\left\{t \in Tasks \,|\, h_t = h\right\} \quad \forall p,h$$

$$\sum_{h} BH_{p,h} = 1 \quad \forall p$$

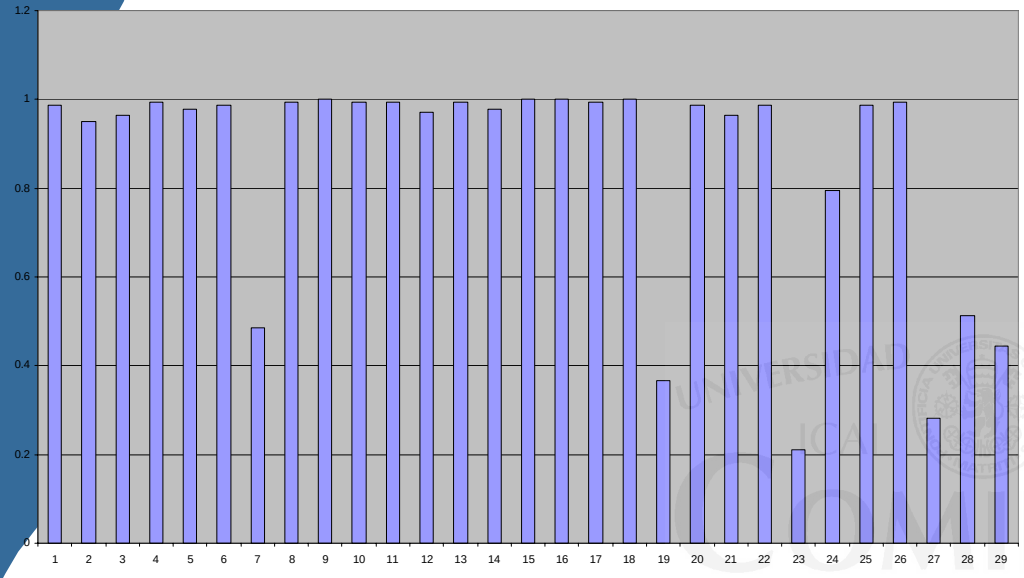
Task Altimetry & Workplace Altimetry

Solving Algorithm

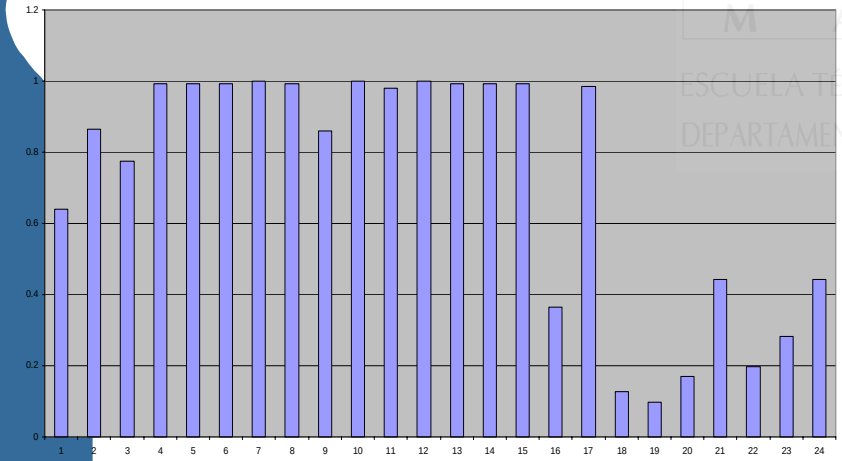
Hybridation between Relaxed Mixed Integer & Constraint Programming



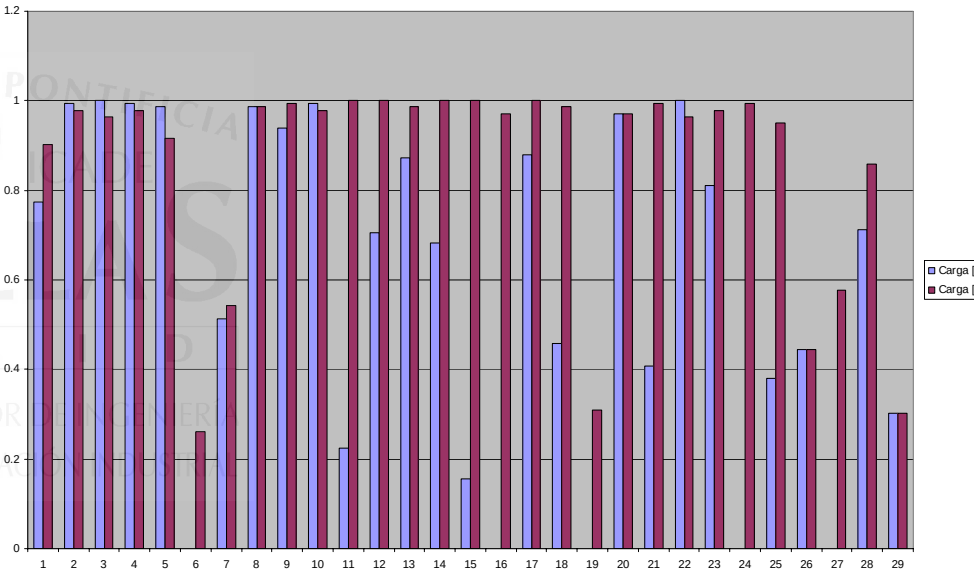
Results



C3



C3P



C3 & C3P