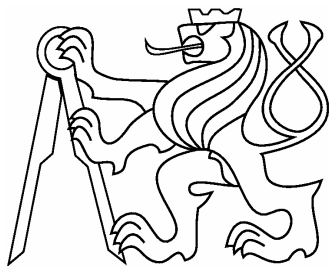# Feeder Setup Optimization in SMT Assembly

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# Introduction

• SMT - Surface Mount Technology

• SMT placement machines are limiting
resource of the production
(due to high purchase cost)
• Therefore, optimization is necessary

• Optimization tools by placement machine
manufacturer
    - not suitable for all needs

In this work:
• Cooperation with a company producing
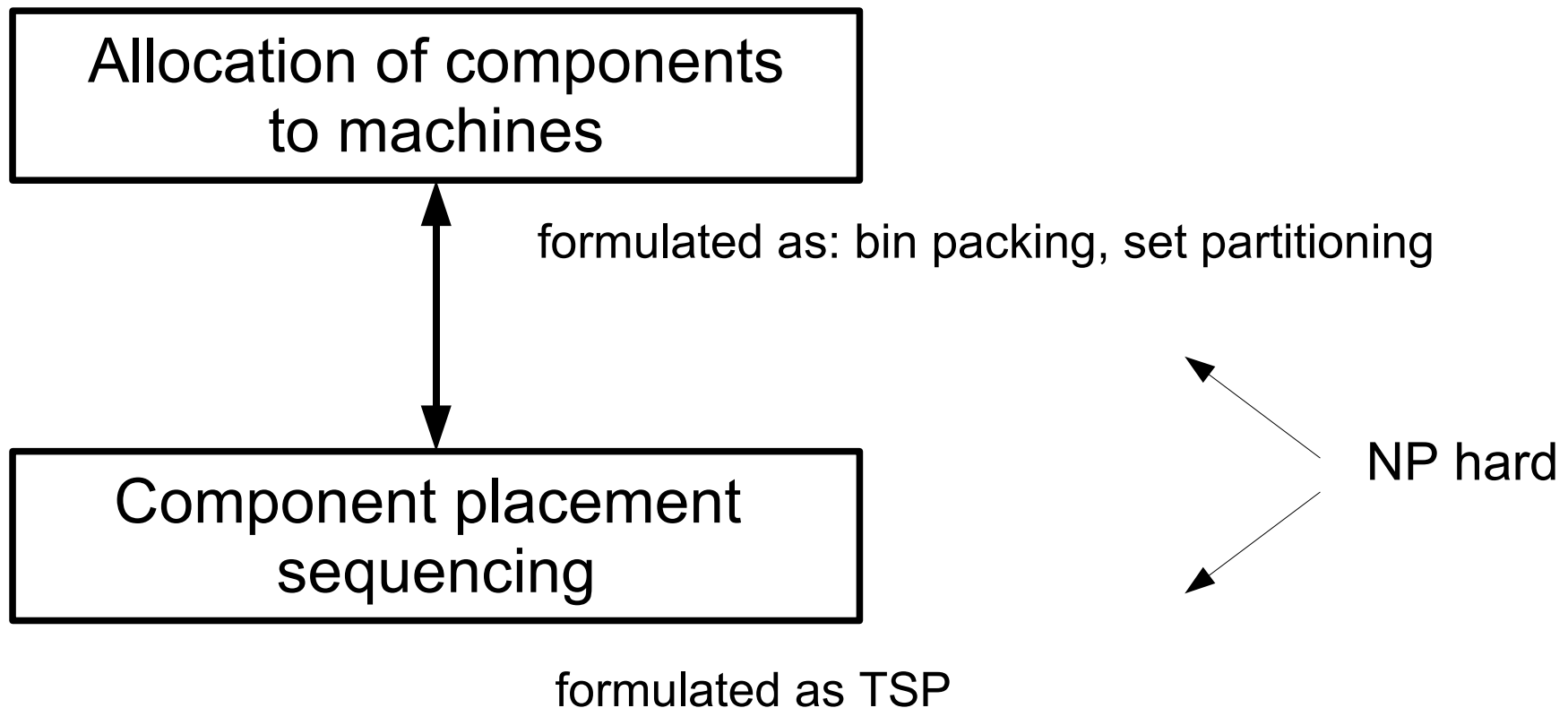power steering controllers for car industry
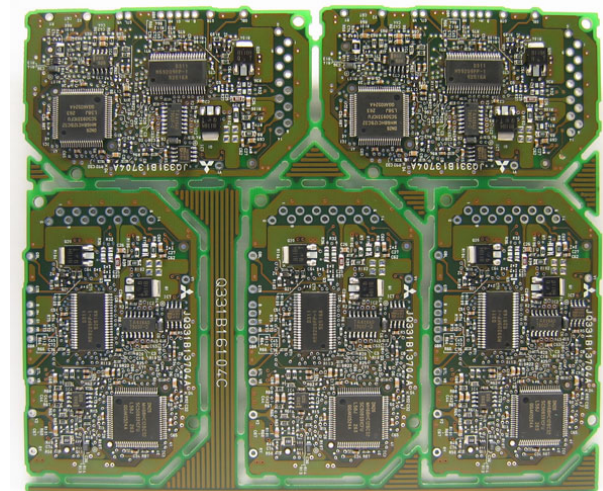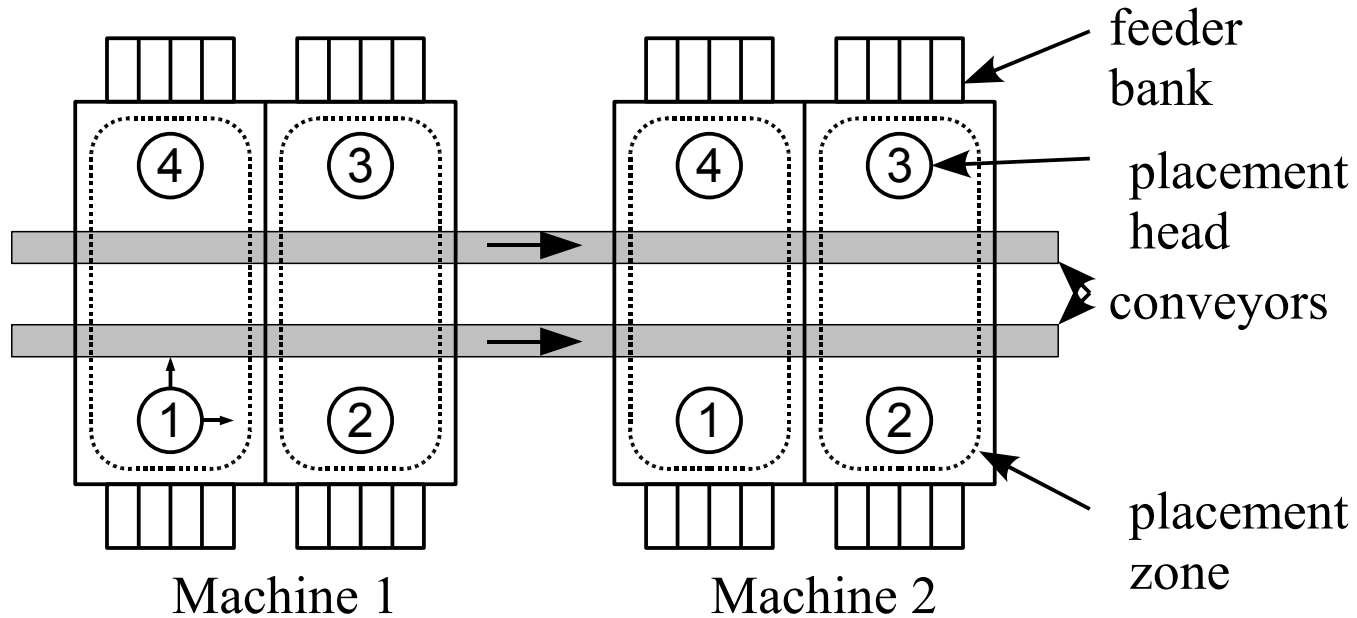
# SMT Assembly Optimization

**Goal:**
- maximize utilization of machines
- i.e. maximize production speed

Two hierarchically related sub-problems:

| Allocation of components to machines |
|:---:|

formulated as: bin packing, set partitioning

| Component placement sequencing |
|:---:|

NP hard

formulated as TSP

# SMT Line



feeder bank

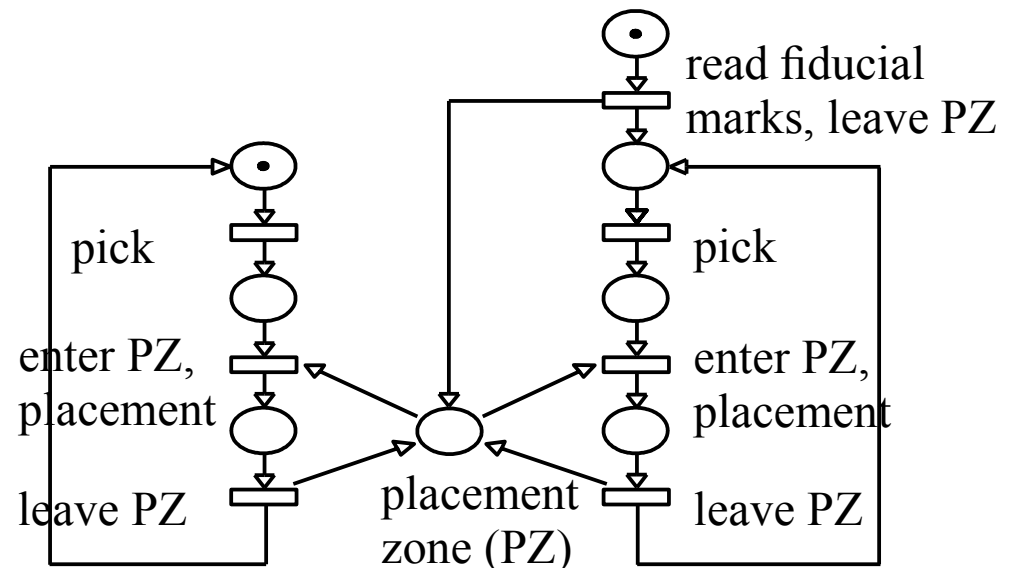placement head

conveyors
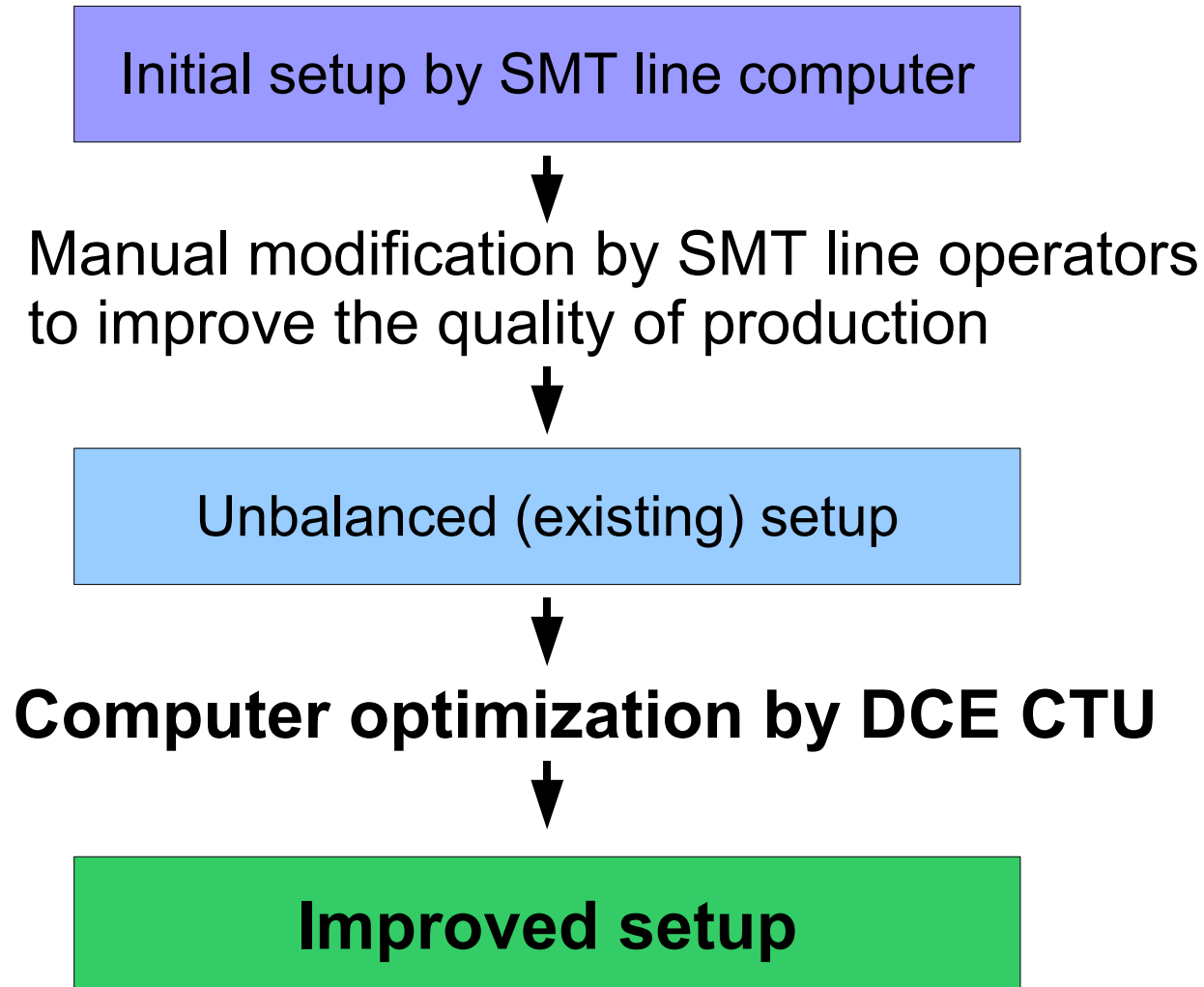
placement zone

Machine 1          Machine 2

- 2 machines
- 4 placement zones
- 8 placement heads

- 12 nozzles per head

Dual delivery operation: synchronization of two heads sharing one placement zone

read fiducial marks, leave PZ

pick                    pick

enter PZ, placement          enter PZ, placement

leave PZ     placement zone (PZ)     leave PZ

# Setup Optimization Problem

Initial setup by SMT line computer

Manual modification by SMT line operators
to improve the quality of production

Unbalanced (existing) setup

**Computer optimization by DCE CTU**

**Improved setup**

# Problem Formulation (1)

Allocation of components to machines

Component placement sequencing
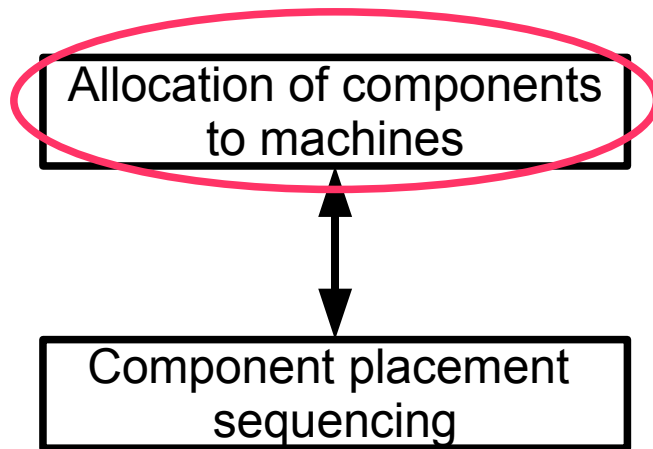
- Allocation of components only
- Unit placement times
- Zero movement time between placement positions

**Problem**:
- Balance the number of components allocated to each placement head
- Consider the 12 component placement cycles
- As few changes in allocation as possible
    changes can have bad effect on product quality

# Problem Formulation (2)

**Number Partitioning Problem (NPP)**
Divide a set $S$ of positive integer numbers into $k$ subsets, so that the difference between the largest and smallest subset sum is minimized.

**Additional constraints:**
- lower and upper bound on the subset sum
- binary variable $x_i$ indicating change in assignment

$(x_i = 0) \Rightarrow$ (assignment not changed)         implication constraint

- upper bound on the sum of $x_i$, i.e. number of changes
- nozzle constraint - each components require one type of nozzle, nozzle changes are not allowed

Implemented in constraint programming system.

# Balancing the number of components
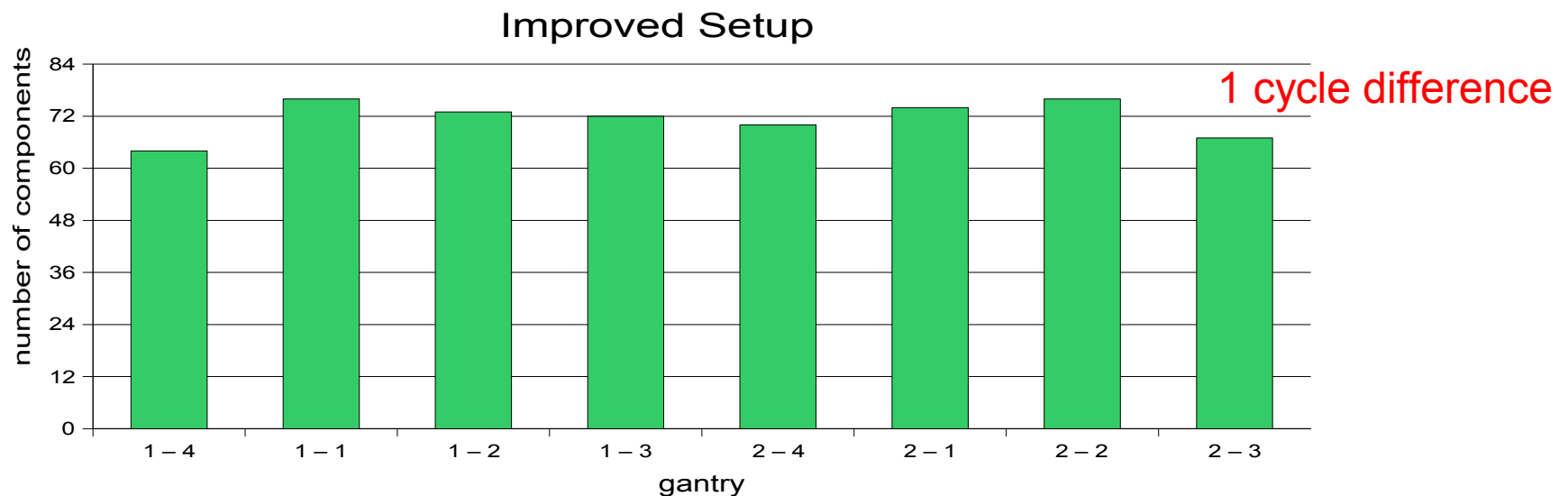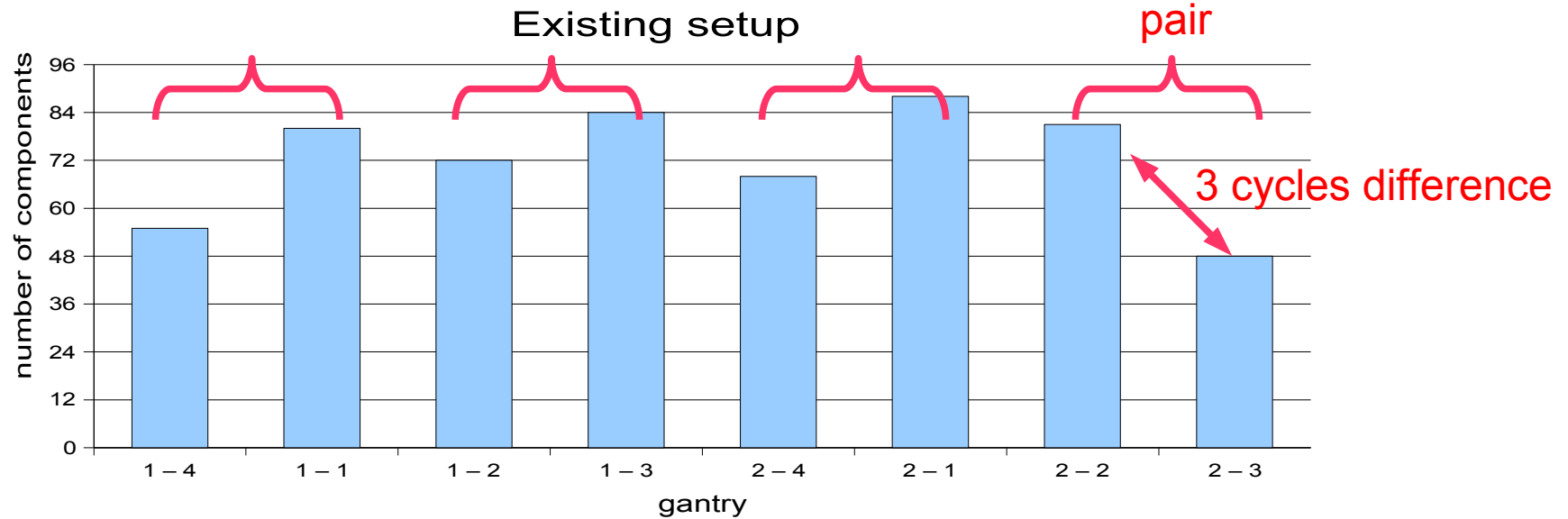
# Results and Conclusion

Results from the production trial:

| | Existing | Trial | Difference |
|---|---|---|---|
| Maximum time [s] | 34,1 | 30,5 | -3,6 |
| Balance ratio [%] | 83,4 | 89,5 | + 6,1 |

- The trial confirmed the improvement in SMT line throughput.
- Consider sequencing problem for better results.

- Future work depends on the requirements of our industrial partner