# 자동화 크로스도킹터미널에서의 출고 위치 결정

최은진, 이희정, 이해경, 고창성†

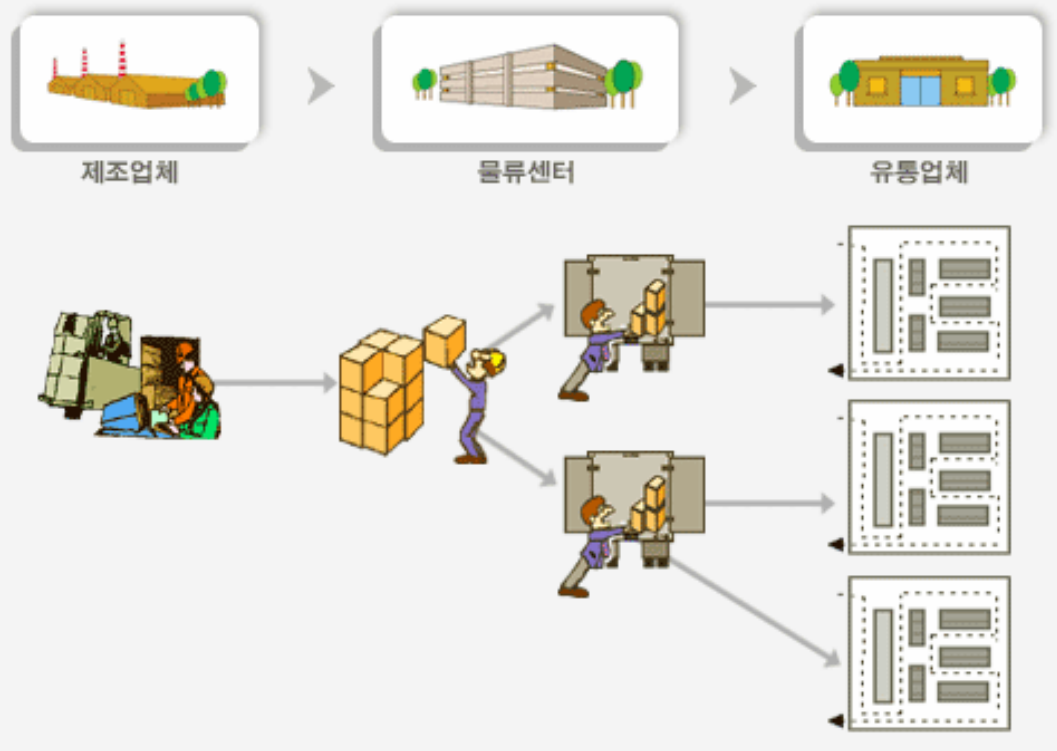
경성대학교 산업공학과

†주저자

본 연구는 **2006**년 학술진흥재단 지역대학 우수과학자 지원사업으로 수행되었음

# Background

## Cross-docking Terminal?

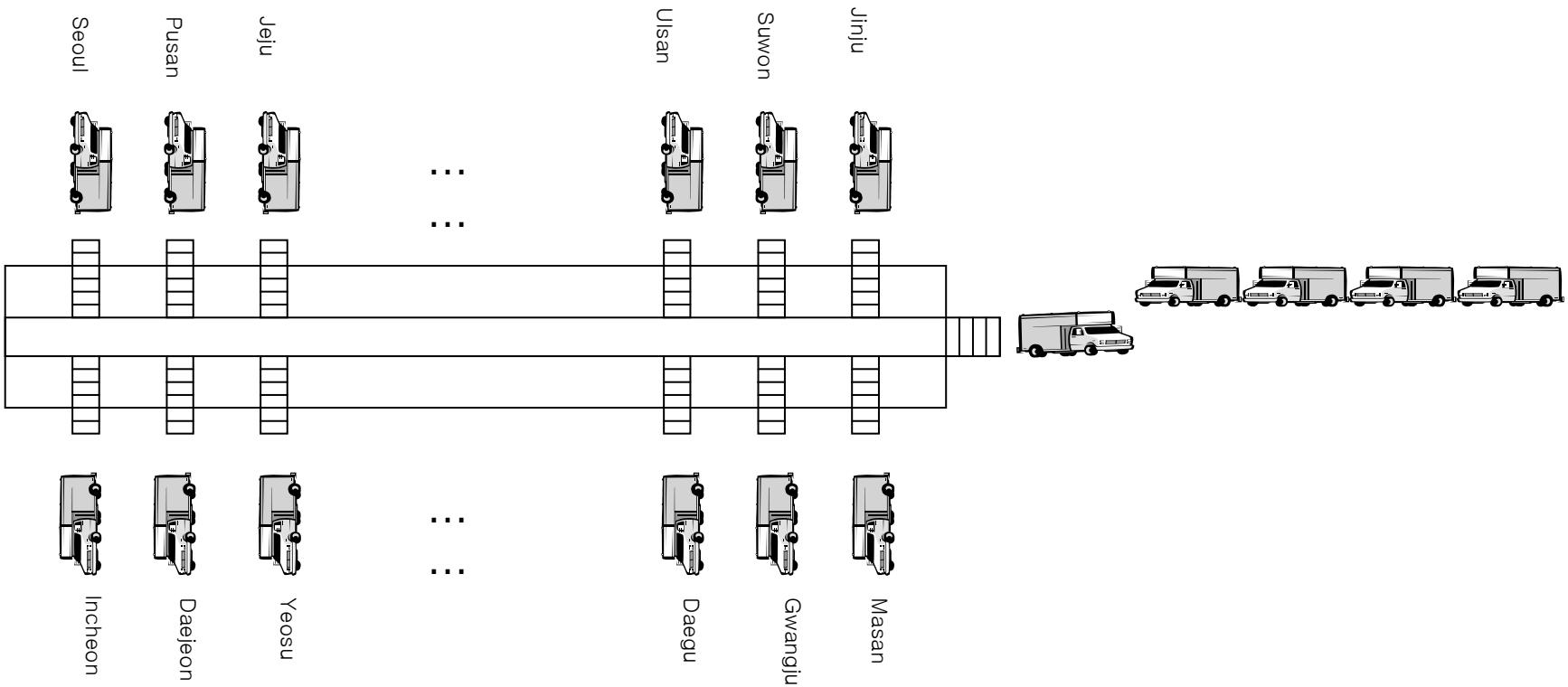



http://blog.naver.com/lovekorea200/40026991406

- Mail distribution
- Express Courier Service → Consolidation Terminal
- Distribution Center → Cross-docking Terminal

# Background (cont'd)

## Operation in Cross-docking Terminal



# Objective

To assign destinations to shipping dock doors in order to minimize both the number of workers engaged in loading operation and the imbalance ratio among the workers.

- Mathematical Model
- Heuristic Algorithm
  - -genetic algorithm
  - -line balancing heuristic
- An illustrative example

# Literature Review

- Tsui and Chang (1990, 1992)
- Kinnear (1997)
- Sung and Song (2003)
- Oh Yonghui et al. (2006)

# Model Development

- Model Parameters

| | |
|---|---|
| $f_{it}$ : | freight quantity to destination $i$ over working period $t$ |
| $F_{tk}$ : | workload of working group $k$ over working period $t$ |
| $W$ : | loading capability of a worker per working period |
| $G_t$ : | imbalance ratio over working period $t$ |
| $M$ : | an arbitrary large number |
| $x_{ij}$ : | 1, if destination $i$ is assigned to shipping dock door $j$; 0, otherwise. |
| $y_{jk}$ : | 1, if shipping dock door $j$ is assigned to working group $k$ over working period $t$; 0, otherwise. |

- Indices

| | |
|---|---|
| $t$ : | index of working periods, $t = \{1, 2, ..., T\}$ |
| $i$ : | index of destinations, $i = \{1, 2, ..., N\}$ |
| $j$ : | index of shipping dock doors, $j = \{1, 2, ..., N\}$ |
| $k$ : | index of working groups, $k = \{1, 2, ..., K_t\}$ |

# Model Development (cont'd)

Minimize

$$\sum_{t=1}^{T} K_t / T + \sum_{T=1}^{T} G_t / T \qquad (1)$$

Subject to

$$\sum_{i=1}^{N} x_{ij} = 1, \quad \text{for} \quad j = 1, 2, .., N \qquad (2)$$

$$\sum_{j=1}^{N} x_{ij} = 1, \quad \text{for} \quad i = 1, 2, ..., N \qquad (3)$$

$$\sum_{k=1}^{K_t} y_{tjk} = 1, \quad \text{for} \quad t = 1, 2, ..., T \quad \text{and} \quad j = 1, 2, .., T \qquad (4)$$

$$\sum_{j=1}^{K} y_{tjk} \geq 1, \quad \text{for} \quad t = 1, 2, ..., T \quad \text{and} \quad k = 1, 2, ..., K_t \qquad (5)$$

$$\left( \sum_{j=1}^{j-1} y_{tjk} \right) \left( \sum_{j=j+1}^{N} y_{tjk} \right) \leq M \cdot y_{tjk}, \quad \text{for} \quad t = 1, 2, ..., T, \quad k = 1, 2, ..., K_t, \text{ and } \quad j = 2, 3, ..., (N-1) \qquad (6)$$

$$F_{tk} \leq W, \quad \text{for} \quad t = 1, 2, ..., T \quad \text{and} \quad k = 1, 2, ..., K_t \qquad (7)$$

where

$$F_{tk} = \sum_{i=1}^{N} f_{ti} \sum_{j=1}^{N} x_{ij} * y_{tjk}, \quad \text{for} \quad t = 1, 2, ..., T \quad \text{and} \quad k = 1, 2, ..., K_t \qquad (8)$$

$$G_t = \frac{\underset{k=1,2,...,K_t}{Max} F_{tk} - \underset{k=1,2,...,K_t}{Min} F_{tk}}{W}, \quad \text{for} \quad t = 1, 2, ..., T \qquad (9)$$

$x_{jn}$, $y_{nk}$ : binary variables, for $t = 1, 2, ..., T$, $i = 1, 2, ..., N$, $j = 1, 2, .., N$, and $k = 1, 2, ..., K_t$ (10)

# Heuristic Algorithm

## Genetic Algorithm (GA)

Dock Door Assignment

Traveling Salesman Problem (TSP)

-Cloning : 20%

-Parent selection : Binary Tournament Selection

-Crossover : Partial Mapped Crossover (PMX)

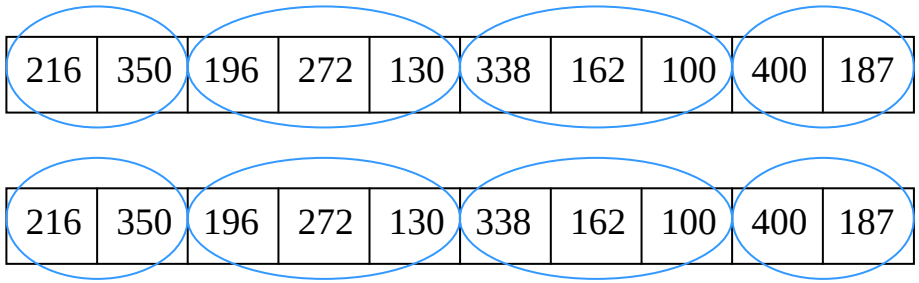
-Mutation : Displacement

-Fitness Function : Objective Function

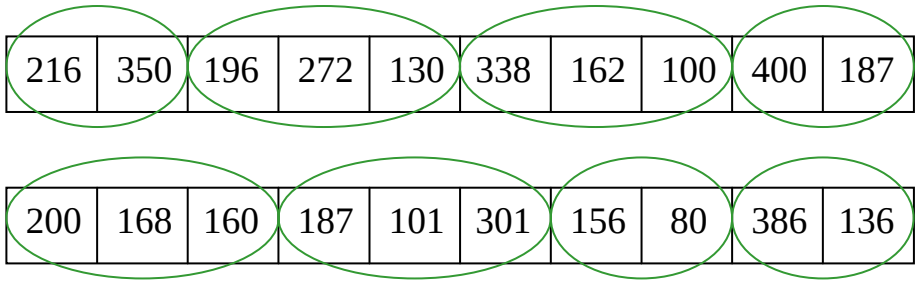
# Heuristic Algorithm (Cont'd)

## line balancing heuristic

Clustering




line balancing




⇨ Agrawal's Heuristic

# An Illustrative Example

- Working period : 4
- Destination : 20
- Capability per worker : 600 units per period.

| | Present | GA |
|---|---|---|
| # of Working groups (Average) | 11 | 9.25 |
| Imbalance Ratio (Average) | 0.48 | 0.06 |

# An Illustrative Example (cont'd)

| Shipping dock door / Working period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | # of working groups | Imbalance ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1st | 196 | 148 | 193 | 149 | 287 | 197 | 191 | 198 | 275 | 150 | 286 | 295 | 275 | 293 | 195 | 281 | 149 | 280 | 289 | 291 | 9 | 0.27 |
| | 537 | | | 436 | | 586 | | | 425 | | 581 | | 568 | | 476 | | 429 | | 580 | | | |
| 2nd | 576 | 589 | 299 | 194 | 195 | 298 | 300 | 302 | 290 | 596 | 187 | 296 | 290 | 187 | 302 | 567 | 565 | 185 | 197 | 579 | 14 | 0.49 |
| | 576 | 589 | 493 | | 493 | | 300 | 592 | | 596 | 483 | | 477 | | 302 | 567 | 565 | 382 | | 579 | | |
| 3rd | 190 | 570 | 189 | 599 | 586 | 145 | 190 | 148 | 296 | 296 | 147 | 199 | 293 | 280 | 150 | 579 | 300 | 286 | 195 | 200 | 13 | 0.75 |
| | 190 | 570 | 189 | 599 | 586 | 483 | | | 592 | | 346 | | 573 | | 150 | 579 | 586 | | 395 | | | |
| 4th | 147 | 196 | 596 | 118 | 120 | 196 | 146 | 200 | 147 | 197 | 590 | 129 | 149 | 190 | 199 | 194 | 193 | 196 | 116 | 115 | 8 | 0.42 |
| | 343 | | 596 | 580 | | | | 544 | | | 590 | 468 | | | 586 | | | 427 | | | | |
| Destination | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | Average | Average |
| | | | | | | | | | | | | | | | | | | | | | 11 | 0.48 |

# An Illustrative Example (cont'd)

| Shipping dock door / Working period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | # of working groups | Imbalance ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1st | 193 | 191 | 196 | 275 | 275 | 148 | 150 | 149 | 149 | 287 | 289 | 291 | 295 | 195 | 197 | 198 | 286 | 293 | 280 | 281 | 8 | 0.08 |
| | 580 | | | 550 | | 596 | | | | 576 | | 586 | | 590 | | | 579 | | 561 | | | |
| 2nd | 299 | 300 | 576 | 290 | 290 | 589 | 596 | 565 | 194 | 195 | 197 | 579 | 296 | 302 | 298 | 302 | 187 | 187 | 185 | 567 | 12 | 0.07 |
| | 599 | | 576 | 580 | | 589 | 596 | 565 | 586 | | | 579 | 598 | 600 | | | 559 | | | 567 | | |
| 3rd | 189 | 190 | 190 | 293 | 296 | 570 | 296 | 300 | 599 | 586 | 195 | 200 | 199 | 150 | 145 | 148 | 147 | 280 | 286 | 579 | 10 | 0.06 |
| | 569 | | | 589 | | 570 | 596 | | 599 | 586 | 594 | | | 594 | | | 566 | | | 579 | | |
| 4th | 596 | 146 | 147 | 149 | 147 | 196 | 197 | 193 | 118 | 120 | 116 | 115 | 129 | 199 | 196 | 200 | 590 | 190 | 196 | 194 | 7 | 0.03 |
| | 596 | 589 | | | | 586 | | | 598 | | | | | 595 | | | 590 | 580 | | | | |
| Destination | C | G | A | M | I | B | J | Q | D | E | S | T | L | O | F | H | K | N | R | P | Average 9.25 | Average 0.06 |

# Conclusion

To assign destinations to shipping dock doors in order to minimize both the number of workers engaged in loading operation and the imbalance ratio among the workers.

- Mathematical Model
- Heuristic Algorithm
  - -genetic algorithm
  - -line balancing heuristic
- An illustrative example

**Future research Area**

- Case Study
- Heuristic Algorithm