Optimization of operations in container terminals

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MOTIVATION
International sea-freight container transportation has grown dramatically over the last years and terminals have to face with an increasing competitiveness in the sector.

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<tbody>
<tr>
<td>1 Singapore</td>
<td>21,932</td>
<td>24,792 (+16%)</td>
<td>29,918 (+21%)</td>
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<tr>
<td>2 Shanghai</td>
<td>14,557</td>
<td>21,710 (+49%)</td>
<td>27,980 (+29%)</td>
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<tr>
<td>3 Hong Kong</td>
<td>21,984</td>
<td>23,539 (+07%)</td>
<td>24,248 (+03%)</td>
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<tr>
<td>Europe</td>
<td>2004</td>
<td>2006</td>
<td>2008</td>
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<tr>
<td>1 Rotterdam</td>
<td>8,291</td>
<td>9,655 (+17%)</td>
<td>10,784 (+12%)</td>
</tr>
<tr>
<td>2 Hamburg</td>
<td>7,003</td>
<td>8,862 (+27%)</td>
<td>9,737 (+16%)</td>
</tr>
<tr>
<td>3 Antwerp</td>
<td>6,064</td>
<td>7,019 (+16%)</td>
<td>8,663 (+23%)</td>
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Container traffic (in thousands TEU).
Optimization techniques are therefore needed to improve productivity and efficiency in container terminal operations.

OBJECTIVE
To propose new solution methods for the following problems:

1. Berth Allocation Problem (BAP): to assign and to schedule ships to berths over a time horizon, according to an expected handling time.

2. Quay Crane Assignment Problem (QCAP): to assign quay cranes (QC) to the ships as scheduled by the given berth allocation plan, taking into account the capacity constraint in terms of available QCs.

Remark: BAP and QCAP are usually solved hierarchically.

CONTRIBUTION

- Integration of operations: our model optimizes the BAP and the QCAP simultaneously, leading to a significant cost reduction for the terminal.
- Yard housekeeping costs: our model takes into account the cost generated to move containers in terms of traveled distance quay-yard-quay, in the context of a transshipment container terminal.

MATHEMATICAL MODEL & SOLUTION TECHNIQUES

- Mixed integer quadratic problem formulation
- Linearization of the objective function
- Heuristic solution algorithm (tabu search and mathematical programming)
- Working on exact methods and lower bounds