Optimization at Container Terminals

Status, Trends and Perspectives

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Outline

- Introduction
- Planning levels
- Terminal operations
- Yard optimization
- Issues in yard management
- Transshipment: a new approach
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Introduction

- Growth of container sea-freight transportation.
- Competition among terminals in terms of:
  - Service (ship's turnaround time);
  - Productivity (TEUs per year).
- Issues: traffic, congestion and capacity limits.
- OR techniques can improve the efficiency of terminal operations.

Planning Levels at Container Terminals

- Strategic Level

  Long-term decisions regarding:

  - Resources (terminal's equipment, infrastructure, layout etc.);
  - Strategic alliances with shipping companies and other terminals.

- Tactical Level

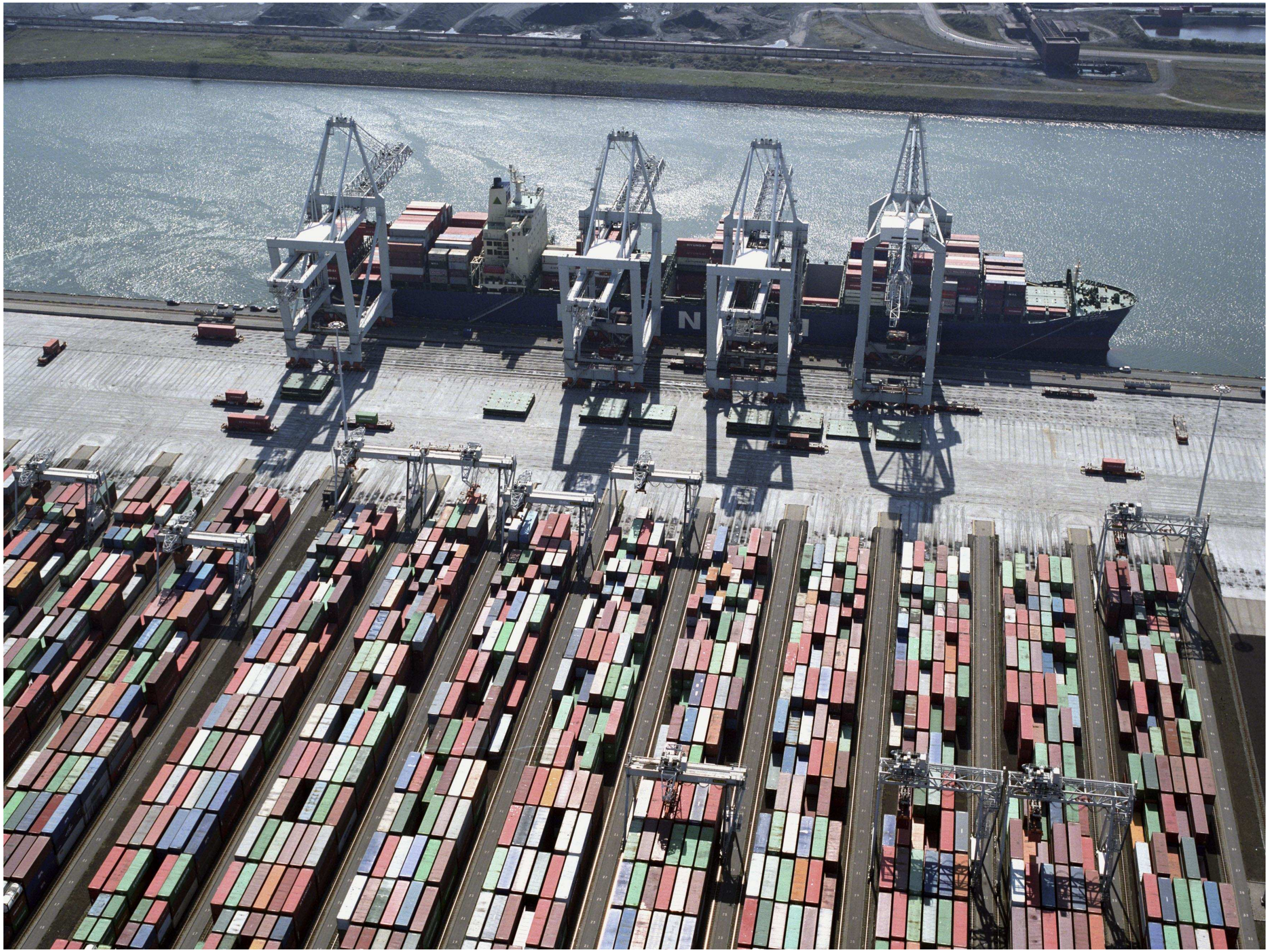
  Mid-term and short-term decisions regarding:

  - Size of the equipment fleet;
  - Storage policies for containers;
  - Berth and yard templates.

- Operational Level

  Daily and real-time decisions regarding all the terminal operations.

Terminal Overview



Terminal Operations

- Ship-to-Shore

  Berth Allocation; Quay Cranes Scheduling; Ship Loading Plan.

- Transfer

  Quay-Yard; Yard-Yard; Yard-Gate.

- Storage

  Yard Management (Block and Bay Allocation); Yard Crane Deployment

- Delivery and Receipt

  Gate management; Interface with trains and trucks.

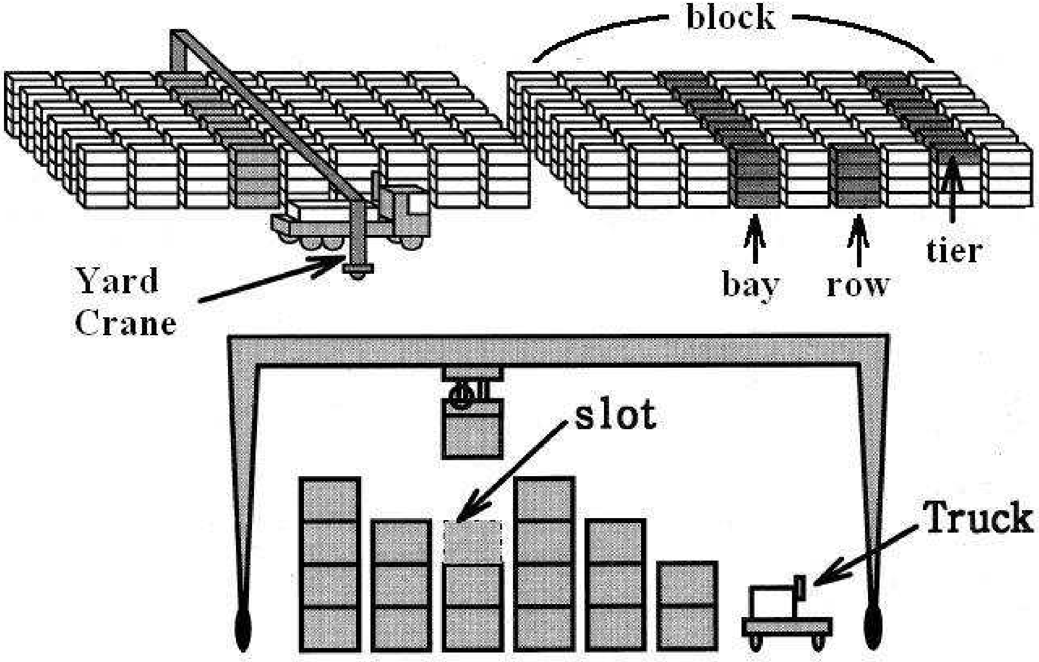
In addition to the traditional flow: transshipment containers.

Vis and de Koster (2003); Steenken et al. (2004); Henesey (2006).

Yard Overview

The yard serves as a buffer for loading, unloading and transshipping containers.

The yard is separated into blocks. The position of the container inside a block is identified by bay, row and tier.



Yard Optimization

- Storage policies for groups of containers at block and bay level, in order to:
  - balance the workload among blocks;
  - minimize the total distance covered to shift containers from quay to yard.

  de Castilho and Daganzo (1993); Kim et al. (2000); Kim and Park (2003); Zhang et al. (2003); Kim and Hong (2006); Kang et al. (2006); Lee et al. (2006).

- Re-marshalling of containers according the ship loading plan, in order to:
  - speed-up loading operations and thus minimize ship's turnaround time.

  Kim and Bae (1998); Lee and Hsu (2007).

- Yard cranes deployment (allocation of cranes among blocks, routing and scheduling of operations), in order to:
  - minimize the completion time of jobs.

  Kim and Kim (1997); Linn et al. (2003); Zhang et al. (2002); Kim et al. (2003); Ng and Mak (2005); Ng (2005); Kim et al. (2006); Jung and Kim (2006).

Issues in Yard Management

The yard is usually the bottleneck of the terminal.

Traffic, congestion and capacity issues originate from here.

Main issue: the “schedule” of the outgoing flow is unknown to the terminal.

- Import/export terminals: yard management is strictly connected to gate operations (trucks).
- Transshipment terminals: yard management is strictly connected to mother vessels and feeders.

Gate Issues

An import/export terminal: port of Antwerp, Belgium.

Issues:

- unknown dwell time;
- congestion and queues.

Possible solutions:

- Vehicle Booking System (VBS): Southampton, 2005;
- Pricing policies (soft time windows; dwell time).

Transshipment: An Overview

A transshipment terminal: port of Gioia Tauro, Italy.

- Containers are exchanged between mother vessels and feeders.
- Market players: the terminal interacts with big shipping companies and feeders.
- Peculiarities of the transshipment flow:
  - Arrival and departure positions and times can be known in advance;
  - Concurrency of loading and unloading operations.
- Definition of new transshipment-related problems:
  - Service Allocation Problem *(Cordeau et al., 2007)*;
  - Group Allocation Problem *(Moccia and Astorino, 2007)*;
  - Short Sea Shipping: Barge Rotation Planning *(Douma et al., 2007)*.

Transshipment: A New Approach

We introduce:

- Interactions of the terminal with the other market players:
  - Negotiation between terminal and feeders on the arrival time.
- Integration of berth and yard planning:
  - Simultaneous assignment of berths and blocks in the yard to the feeders.

Research plan on 2 levels:

1. Optimization

   We assume that the terminal can decide the schedule of feeders.

2. Negotiation

   We aim to support the terminal in its negotiation with ad-hoc pricing policies.

Transshipment: A New Approach

Optimization framework:

1. Berth & Block Allocation Problem (BBAP):
   - Minimize the total distance quay-yard;
   - Balance workload among yard blocks.
2. Scheduling of feeders:
   - Minimize congestion in yard blocks.

- We search for a global optimal solution minimizing the objectives.
- Congestion is minimized given the optimal BBAP.
- A branching strategy explores Pareto-optimal solutions of BBAP.

Conclusions

- Focus on yard management and its interactions with:
  - gate operations;
  - transshipment flow.

- A new approach in the optimization of transshipment operations:
  - combined assignment of berths and blocks to feeders;
  - scheduling of feeders.

- Pricing policies to support the terminal in the negotiation with feeders.

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