Container terminal management and related problems

Lecture pack No. 6B

Basics from theory of scheduling

- n jobs, m machines
- each job j has a given processing time p(j)
- each job j has a given due date d(j)
- completion time of job j= t(j)
- lateness L(j)= t(j)-d(j)
- tardiness T(j)= max(0, L(j))

In our case

- Jobs: ships awaiting service
- Machines: cranes, other equipment (straddle carriers, trucks, etc)

- Processing time: berthing, mooring, unloading, loading, unmooring, departure

Measures of performance

MINIMIZE

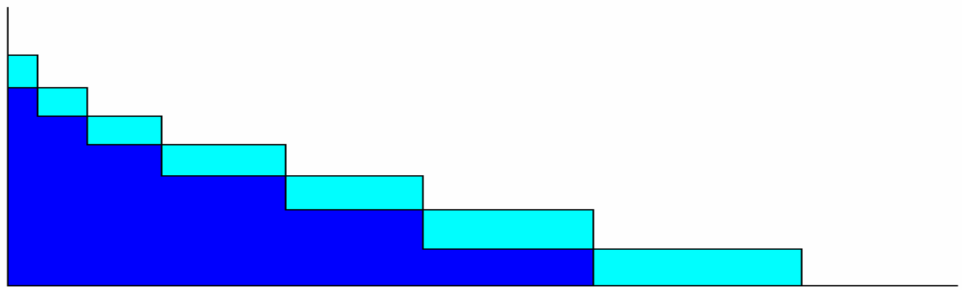
- Maximum completion time (makespan)
- Total completion time
- Average completion time
- Total lateness
- Total tardiness
- Maximum tardiness

1-machine problem

- Makespan independent of sequence
- Which sequence minimizes total completion time?

SPT-rule

- Sequence by non-decreasing order of processing times



SPT rule minimizes also

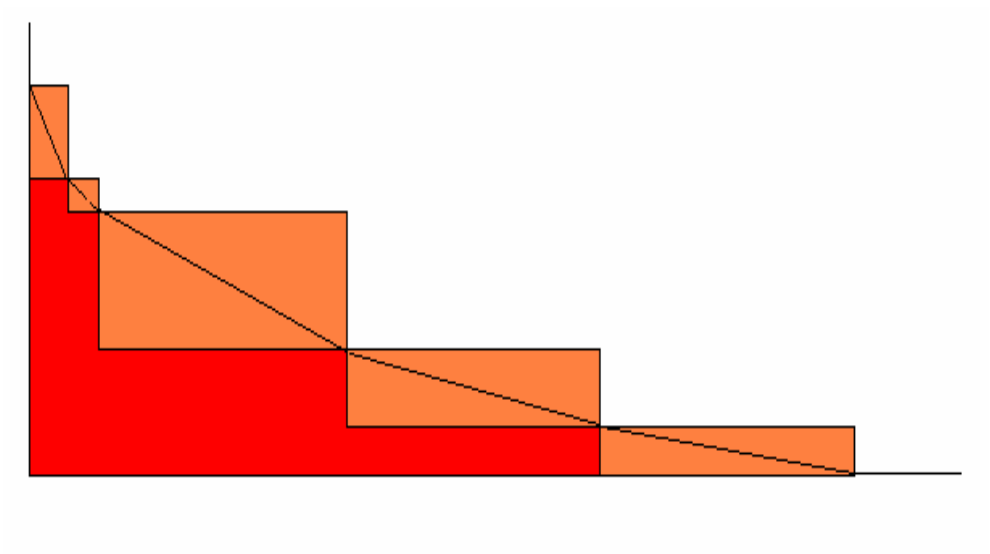
- Average completion time
- Total lateness
- Average lateness

Extension

- If each job j has also a weight w(j)
- Which sequence minimizes total weighted completion time?
- (weight can be cost in $/time)

Modified SPT rule

- Sequence by non-decreasing order of p(j)/w(j) ratios



Due dates

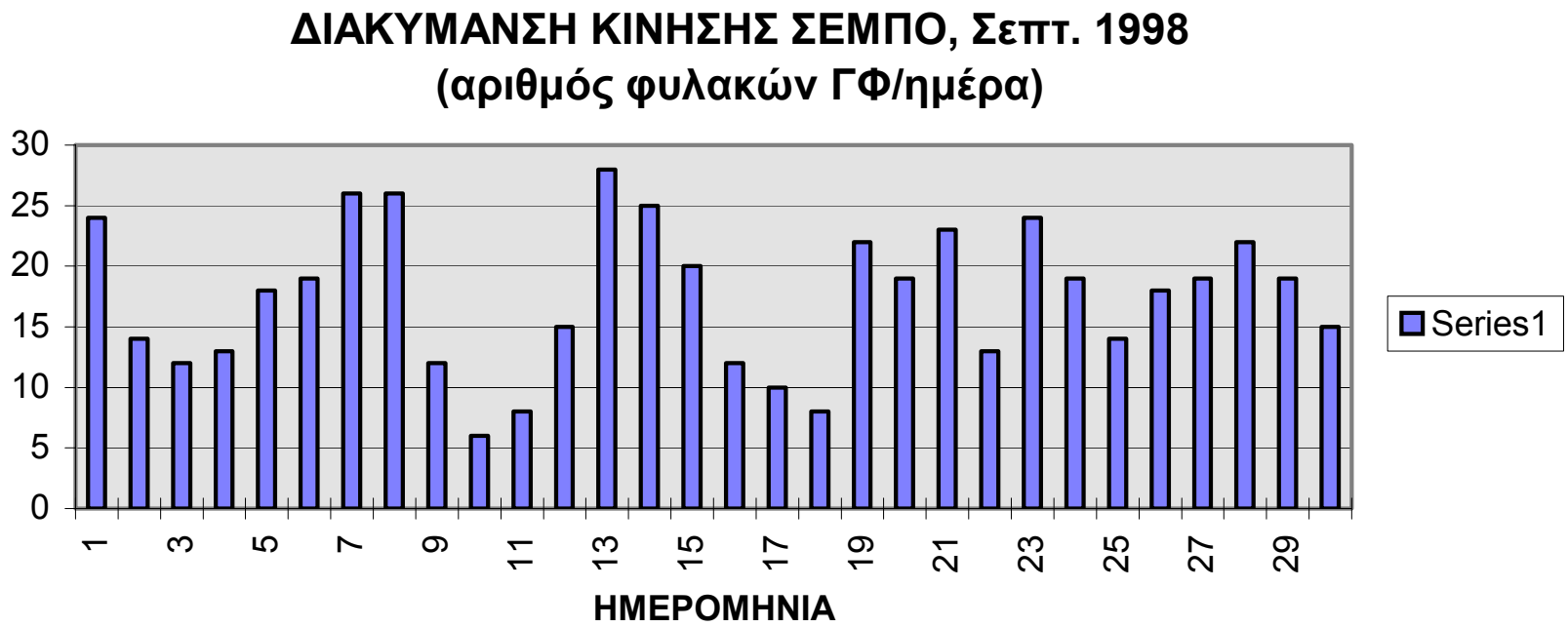
Sequencing by non-decreasing due dates

- Minimizes maximum lateness
- Minimizes maximum tardiness

Scheduling policies (OLP)

- FCFS
- Berthing on arrival
- Rendez-vous system

Rendez vous system



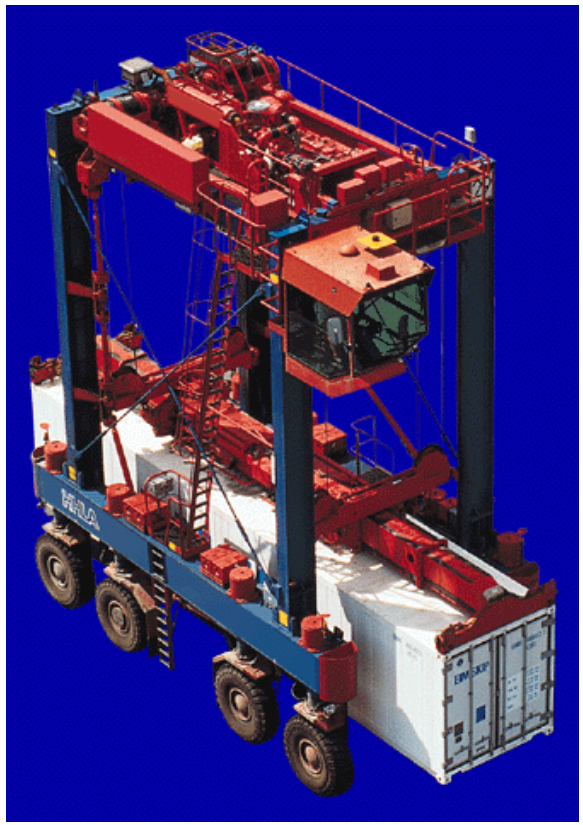
How it works

- Book 5 days to a year in advance
- Ask for specific number of gantry cranes
- Berthing on arrival if punctual
- Lose rendez vous if not
- 30% of terminal capacity allocated to system
- Both for container terminal and car terminal

Benefits

- Eliminate competitive disadvantage vis-à-vis other ports
- Normalize traffic peaks
- Avoid increased infrastructure costs to account for traffic peaks
- Better planning for port users (both to those who use it and to those who don’t)

Routing of straddle carriers



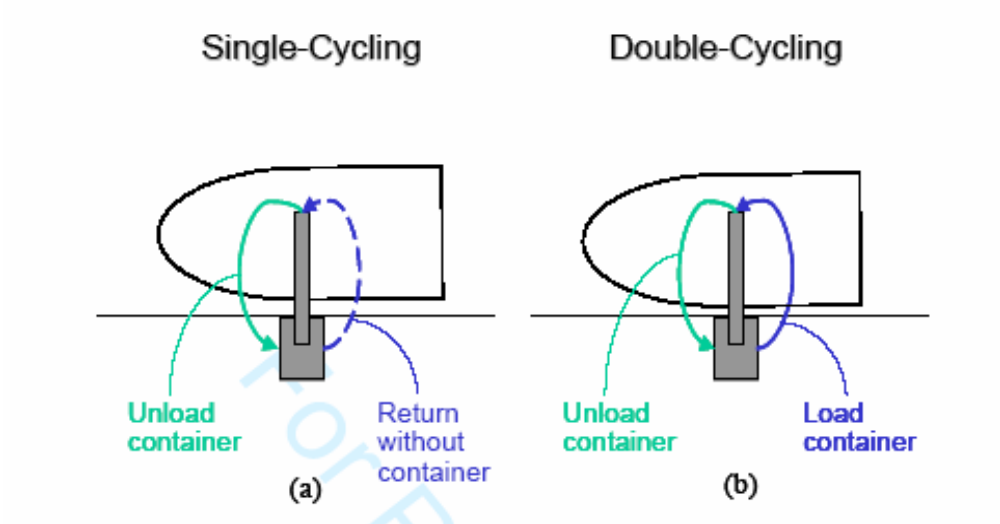
Reference

- Kim & Kim, “An optimal routing algorithm for a transfer crane in port container terminals”, Transportation Science Vol. 33, No. 1, Feb. 1999

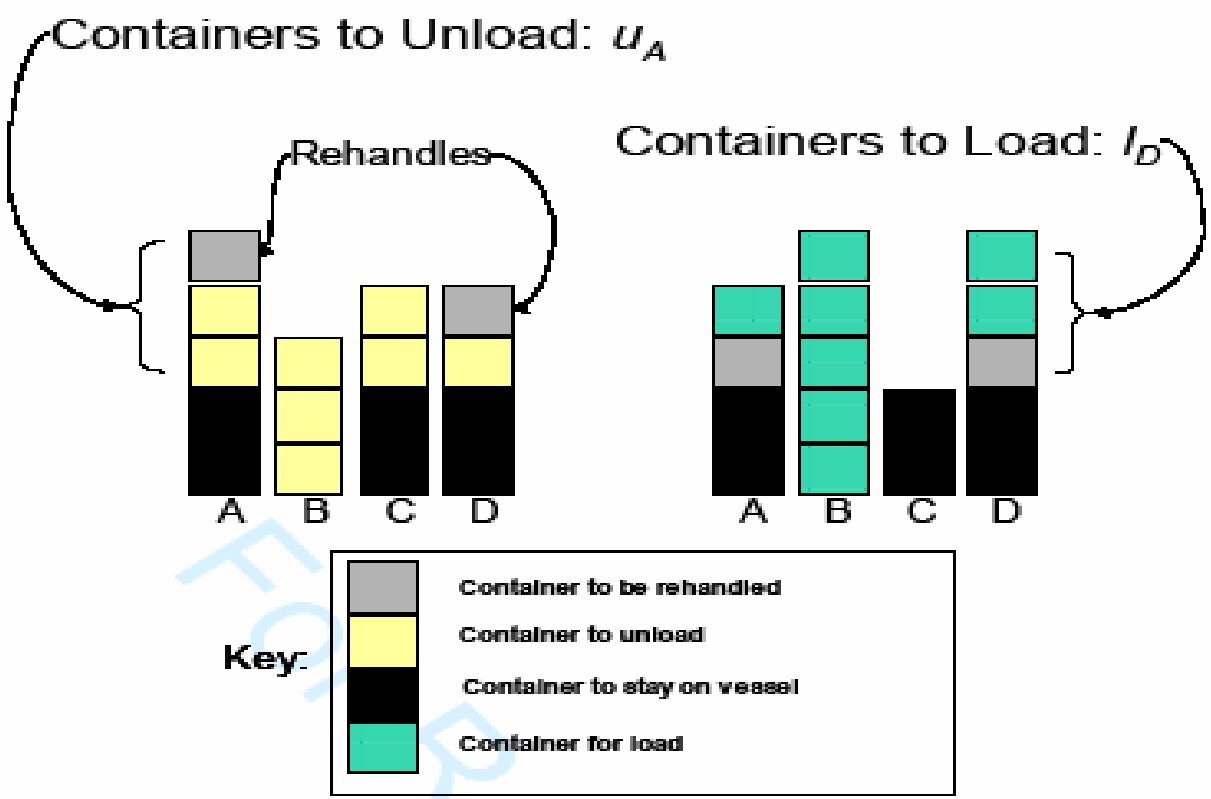
- Objective: minimize total container handling time

Double cycling

- Reference: Goodchild-Daganzo 2005



Optimal loading-unloading



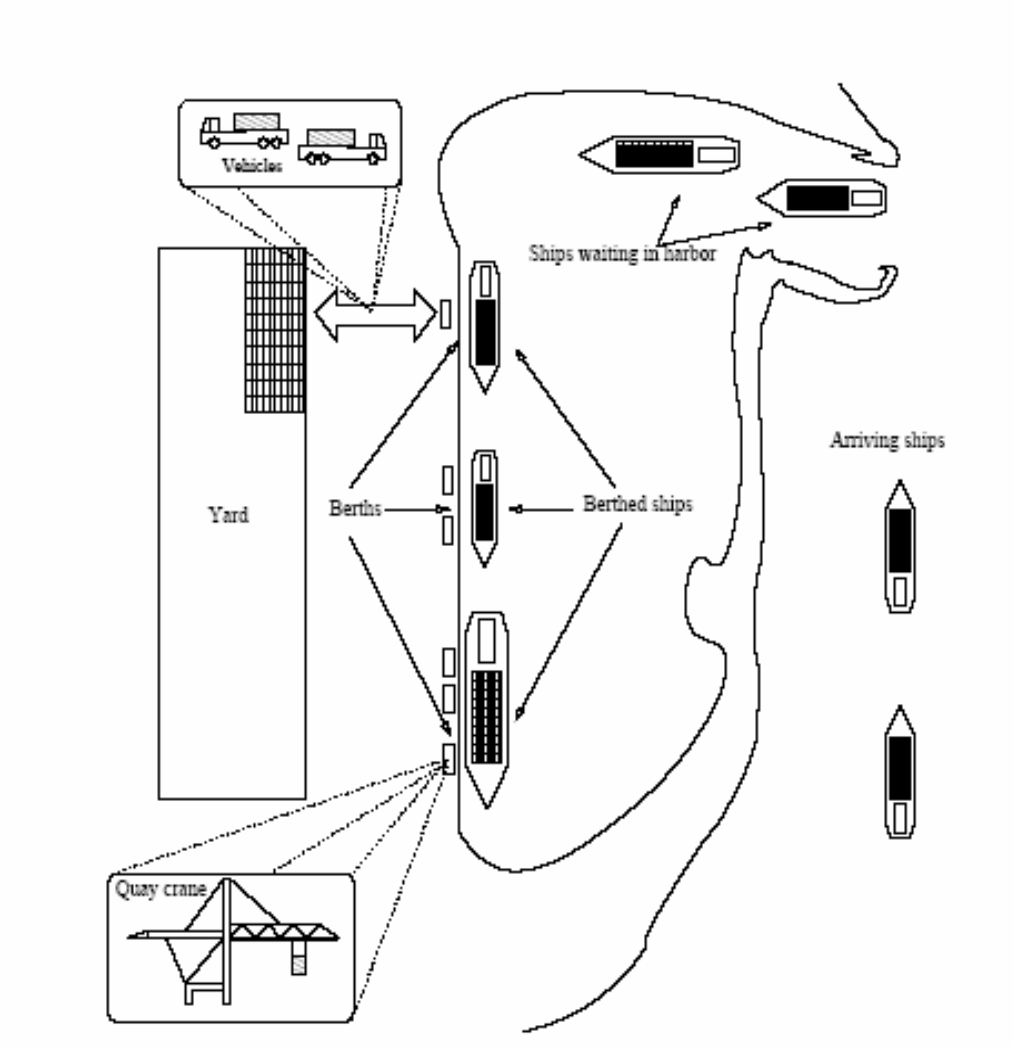
References

- Aslidis, “Optimal container loading”, M.Sc. thesis, MIT, 1983
- Aslidis, “Combinatorial algorithms for stacking problems”, PhD thesis, MIT, 1989

Optimal berthing

- Assign ships to berths
- Assign cranes to ships

- Reference:Cordeau, Laporte, Legato, Moccia, “Models and tabu search heuristics for the berth allocation problem”, Transportation Science (2006)



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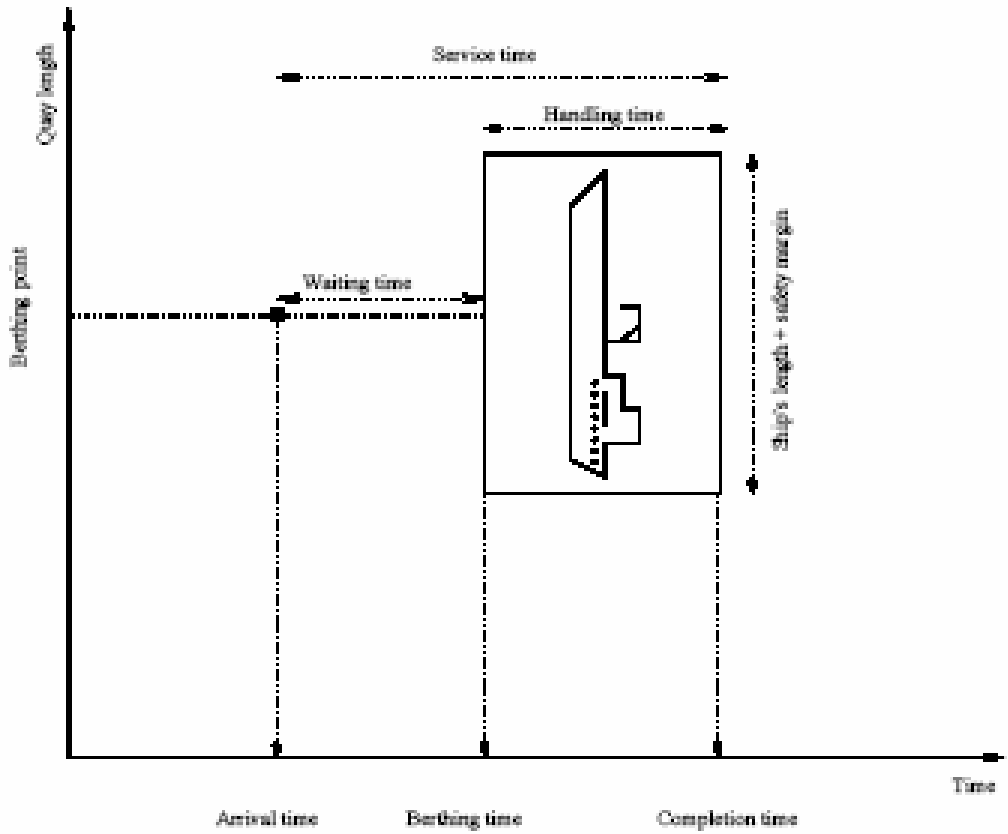

Figure 2: Berth - time space