An integrated framework for quayside operation problem with continuous berths

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There are three kinds of operations for a typical port container terminal: quayside operation, yardside operation, and hinderland operation. One of the issues of quayside operation planning is known as the Berth Allocation Problem (BAP), which is the decision to assign the berthing location and service time to coming ships. In tradeitional fashion, after the decision of the BAP is made, according to the obtained berth layout, quay cranes, the industry-standard equipments which are mounted on the same tracks along the quay, are assigned and scheduled to unload and load containers from and to the ships. In the literature, this part of decision is referred to as the Quay Crane Assignment Problem (QCAP) and the Quay Crane Scheduling Problem (QCSP). Thus, in general terms, the quayside operation planning involves the BAP, the QCAP, and the QCSP.

However, the quayside operation problem is not the simple sum of the three subproblems since they are highly interrelated. To get the insight into this, note that on one hand, the output of the BAP is served as the input for the QCAP and the QCSP; on the other hand, it is only possible to gauge the length of the handling time for each ship which is the key input for the BAP, after solving the QCAP and the QCSP. In light of this observation, to achieve a feasible and better planning for the quayside operation, the integration of the BAP, the QCAP, and the QCSP is extremely necessary and the studies on this problem is a phenomenal trend in this research society in the field of port container terminal management.

After reviewing the existing works in the literature under this topic and identifying the common deficiencies in the previous researches, we develop two Mixed Integer Programming (MIP) mathematical formulations for the proposed integrated quayside operation problem in the case of continuous berths. For solutions, a greedy approach is constructed to solve the proposed problem. Compared with most of the greedy search approaches, the heuristic devised in this paper takes advantage of the current sophisticated MIP solvers, by using them as a black box tool to find out satisfactory feasible solutions as early as possible during the computation. Such strategy is inspired by the work of Fischetti, i.e., local branching. To test the performance of the proposed greedy search algorithm, a comprehensive numerical experiment is conducted. Through the experiment, it is clearly shown that the proposed greedy search approach owns the feature of finding out satisfactory solutions for the proposed quayside operation problem on a low computational time budget. Table 1 shows some results from the experiment.

	Heuristic		CPLEX		Gap(%)
	Obj	Time(s)	Obj	Time(s)	
1	416	110	416	455	0.00
2	425	392	425	5681	0.00
3	318	147	318	128	0.00
4	369	202	369	739	0.00
5	335	517	335	2252	0.00
6	491	273	491	6407	0.00
7	334	50	334	30	0.00
8	483	71	483	527	0.00
9	330	17	330	31	0.00
10	504	440	504	2116	0.00
11	369	18	369	64	0.00
12	448	54	442	5411	1.36
13	351	335	349	561	0.57
14	432	2350	432	4754	0.00
15	397	195	397	3913	0.00
16	301	440	301	735	0.00
17	453	235	452	1932	0.22
18	505	1095	505	6310	0.00
19	421	351	416	4512	1.20
20	401	458	401	2295	0.00

Table 1: Computational results for Instance set 1