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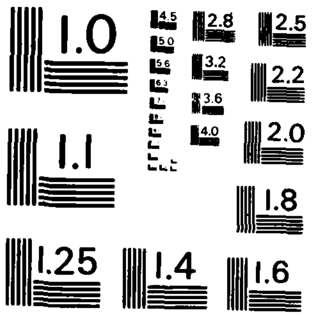

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A HEURISTIC FOR THE PALLET MOVEMENT PROBLEM IN NAVAL SUPPLY

by

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PDRC 83-10

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ABSTRACT

In this paper we develop a heuristic method for the pick-up/delivery problem associated with pallet movements in a Naval Supply Center. The heuristic, based on the insertion technique, was coded on the Cyber 170 and tested on a set of historical data associated with delivery of palletized cargo among warehouses at the ~~Naval Supply Center~~ (NSC), Charleston, S.C. The heuristic tested here was able to improve vehicle utilization by 12.8% over that currently employed.

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I. INTRODUCTION

The pick-up/delivery problem is a commonly occurring model in many military supply applications. This problem involves a set of movement requirements, each with its own origin and destination, and a set of vehicles to satisfy these requirements.

In this paper we develop a heuristic method for the pick-up/delivery problem associated with pallet movements in a Naval Supply Center. The heuristic, based on the insertion technique, was coded on the Cyber 170 and tested on a set of historical data associated with delivery of palletized cargo among warehouses at the Naval Supply Center (NSC), Charleston, S.C.

In the next section, we describe the NSC-Charleston problem and in subsequent sections we present the algorithm and discuss its performance. The Appendices give sample input and output of the computer model.

II. DESCRIPTION OF THE PICK-UP/DELIVERY SYSTEM

The pick-up/delivery problem addressed here involves the scheduling of palletized cargo delivery among warehouses in a Navy Supply Center (NSC). Specifically the pick-up/delivery operations in the NSC-Charleston are examined. The problem in Charleston was first address by Winchell, Melton and Natrella [1]. Most of our knowledge about the operations there somes from the above referred report. So we will describe the system as explained in [1].

In the NSC there exist 86 pick-up and delivery sites and six off-base sites, (Table 1 and Figure 1). Orders are communicated to the dispatch unit located at warehouse 1078. Orders for the palletized cargo movement fall into two priority classes: regular and emergency orders. Each order consists of picking-up a specific number of pallets from an origin site and delivering these to the corresponding destination site.

Having received all the orders for a specific operation period (shift) the task of the dispatcher is to schedule them on the available vehicles. A typical batch of orders is given in Appendix I. Orders are serviced by four types of vehicles: straddle trucks (ST), transporter vehicles (TR), conventional tractor trailers (TT) and industrial tractors (IT). These vehicles are distinguished by their operational characteristics such as speed, loading time, docking time and capacity. Table 2 gives these quantities.

The loading/unloading logic and further constraints on the vehicles are as follows:

TABLE 1 - NSC CHARLESTON WAREHOUSES
LISTED BY GROUP AND NUMBER WITHIN GROUP (*)

Group		
Num	Name(s)	Activity
NORTH		
1	191	NSC
2	1601a	"
3	1601b	"
4	1602	"
5	1603	"
6	1604	"
7	1605	"
8	1606	B279
9	1621	NSC
10	1622	"
11	1628	"
12	A	"
13	1620	"
14	1157	"
CENTR		
15	SM,45	Serve Mart
16	46	6th Nav Dist
17	53C	"
18	64E	NSC
19	64W	"
20	66E	"
21	66W	"
22	67E	"
23	67W	"
24	198	"
25	1078	"
26	1127	"
27	1138	"
28	56	"
29	49	"
30	SF	"
31	SFR	"
NSYN		
32	2	USNSY
33	3	"
34	5	"
35	8	"
36	35	"
37	43C	"
38	44	"
39	59	"
40	223	"

Group		
Num	Names(s)	Activity
WEST		
41	1502	NSC
42	1503	"
43	1507	"
NSWT		
44	80	USNSY
45	177	"
46	1143	Spec Serv
47	1199	USNSY
NSYC		
48	98	NSC
49	187	USNSY
50	216	"
51	1175	"
52	1169	"
53	1171	"
54	1172	S.O.A.P.
55	1173	NSC
56	1174	USNSY
57	218	"
NSYS		
58	X10	AS17
59	193	NSC
60	224	USNSY
61	L	PIER
62	M	"
63	N	"
64	P	"
65	Q	"
66	R	"
67	S	"
68	T	"
69	X20	
SOUTH		
70	30	RTC1
71	43S	not used
72	61	FBMTC
73	84	Comm.Ctr.
74	202	RTC1
75	646	USNS
76	647	"
77	655	Comm.Store
78	656	Navy Ex.
79	52	"

* Source [1]

TABLE 1 (continued)

Group		
Num	Name(s)	Activity
	MCRFT	
80	1	Mine Craft
81	7	"
82	16	"
83	23	"
84	26	"
85	53S	"
	X54	
86	X54	Comm.Ctr.
	OFF BASE	
87	ABASE	Air base
88	NWS	Nav Weap Sta
89	DEYTN	Deytens SY
90	BRASW	Braswell SY
91	CSNWS	ComStoreNWS
92	NMEDC	Nav Hosp

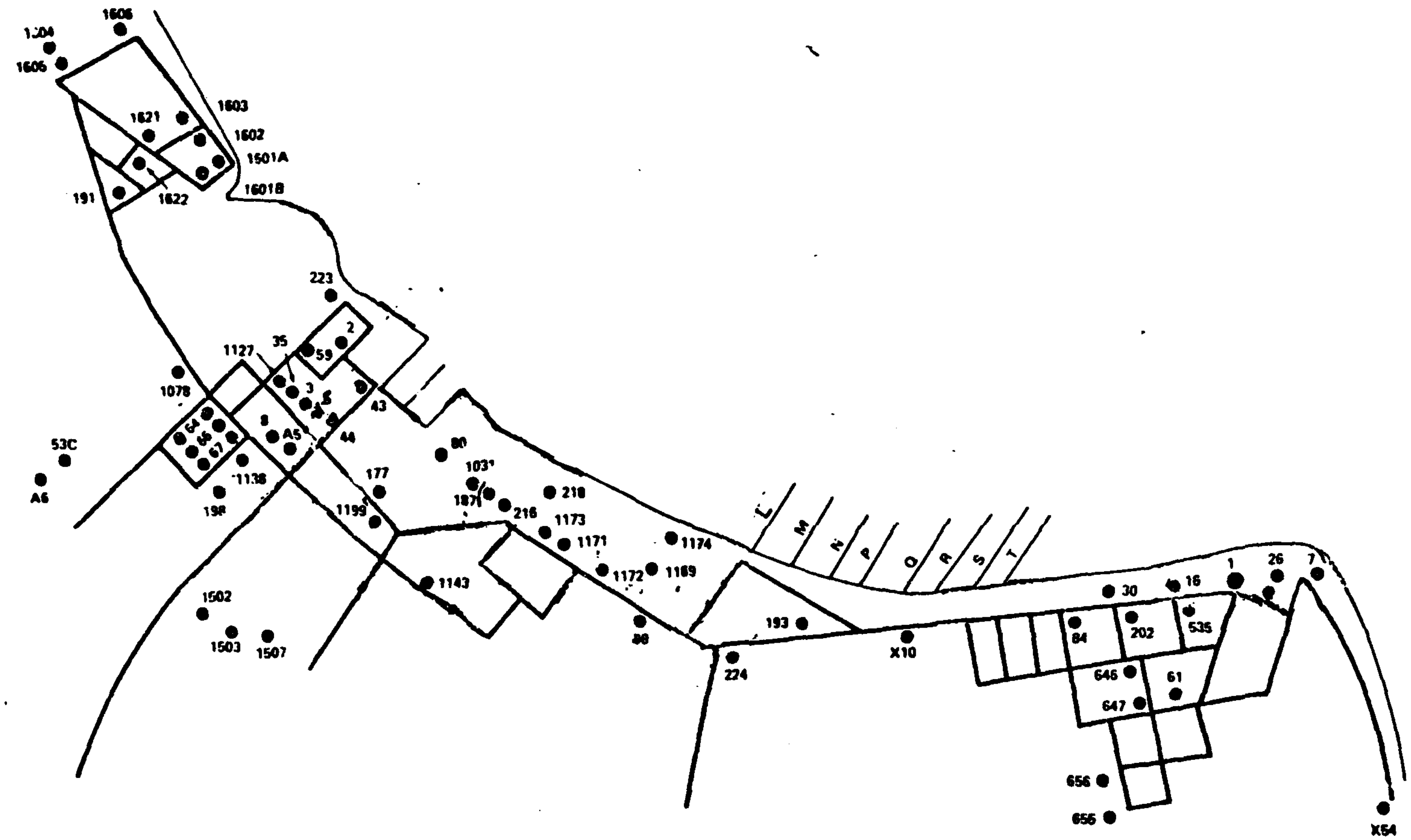

Figure 1 - Map of Charleston Navy Base - Serviced Warhouses (*)

(*) Source [1]

Table 2. Operational Characteristics of Vehicle Types

Vehicle Transporter	Capacity (no. of pallets)	Min. Capacity (no. of pallets)	Docking Time (min.)	Loading Time (min.)
Straddle Trucks(ST)	7	5	1.7	.2
Transporter Trucks(TR)	12	8	1.7	.8
Tractor Trailers(TT)	14	16	5.0	1.7
Industrial Trucks(IT)	10	6	5.0	1.7

1. A minimum order split is assumed.
2. ST/TR's
   a) Any number of pick-up sites
   b) Maximum of two delivery sites per order run
3. ST's are loaded with a "first on, first off" (FIFO) strategy. Others use "first on, last off" (FILO) strategy.
4. ST/TR's pick-up cargo until full or minimum load requirement is met, then delivery begins.
5. TT's are used in offbase deliveries only.
6. Each vehicle must not exceed the maximum route duration.

The following technique was used by the Navy to compute the travel times between warehouses for each vehicle type:

> *"The major reduction in the time array sizes is achieved by grouping the warehouse sites: each group of warehouses in close proximity is considered a single site (area). Table 1 shows the groupings of the Charleston sites. (These groupings reflect some functional as well as geographic differentiation.) The travel time between warehouses within an area are taken to be constant (two minutes).*
>
> *A further reduction in the time array sizes is gained by considering the six off-base sites separately. These sites are serviced only by TT's and all movements take place between off-base locations. The number of measurements necessary to represent t[illegible] to the off-base sites is thus reduced to six."* [1].

Since our only source of data was [1], we used the technique described above to compute the interwarehouse travel times. For each vehicle type, the travel times between areas are given in Tables 3 through 6.

Table 3. Travel Times between Areas: Straddle Trucks and Industrial Tractor (Travel Time in Mins.)

		1	2	3	4	5	6	7	8	9	10
	1		9	11	13	13	18	23	30	27	31
	2			7	6	7	9	12	20	26	29
	3				8	7	9	14	22	26	29
A	4					9	12	20	26	28	32
R	5						6	11	16	21	24
E	6							8	14	15	18
A	7								9	11	12
	8									8	12
	9										7
	10										

Table 4. Travel Times between Areas: Transporters (travel time between areas in mins.)

		1	2	3	4	5	6	7	8	9	10
	1		7	9	11	11	16	21	28	25	29
	2			5	4	5	7	10	18	24	27
	3				6	5	7	12	20	24	27
A	4					7	10	18	24	26	30
R	5						4	9	14	19	22
E	6							6	12	13	16
A	7								7	9	10
	8									5	7
	9										5

Table 5. Travel Times between Areas: Tractor Trailer Trucks (travel time between areas in mins.)

		1	2	3	4	5	6	7	8	9	10
	1		7	9	11	11	16	21	28	25	29
	2			5	4	5	7	10	18	24	27
	3				6	5	7	12	20	24	27
A	4					7	10	18	24	26	30
R	5						4	9	14	19	22
E	6							6	12	13	16
A	7								7	9	10
	8									5	7
	9										5

Table 6. Travel Times Off Base

AREA	OFF-BASE SITE	TRAVEL TIME FROM MAIN BASE(MINS)
11	ABASE	30
12	NWS	45
13	DEYTN	50
14	BRASW	25
15	CS NWS	35
16	NMEDC	15

III. Methodology

For the scheduling of the pick-up and delivery operations, a heuristic procedure is developed. In order to clarify the forthcoming discussion, it is useful to describe the following terminology.

1) Vehicle Route: A vehicle route consists of a set of nodes visited by the vehicle. A route starts at the base warehouse and ends at that same warehouse. For every pick-up (origin) node there must be a corresponding delivery (destination) node on the route (Figure 2).

2) Route Segment: A route segment is a series of nodes on the route where the vehicle is empty at the beginning and ending nodes (Figure 2).

3) Insertion into a Route: For an order, the pair of nodes (origin, destination) are inserted to a route as follows. First the origin node is inserted into some position (.e., between two suitable nodes) and then by using the loading scheme (FIFO or FILO) the position where the destination node will be inserted is determined. Basically there exists two types of insertions - within segments and between segments (Figure 3).

The routing and scheduling procedure developed is a variant of the insetion heuristic. It proceeds iteratively by inserting an order (or a part of an order) to one of the existing vehicle routes at each step. At each iteration every uncompleted order is considered for possible insertion into each of the vehicle routes. for each possible insertion a measure of performance, discussed later, is computed. The insertion with the best performance measure is implemented at the end of each iteration.

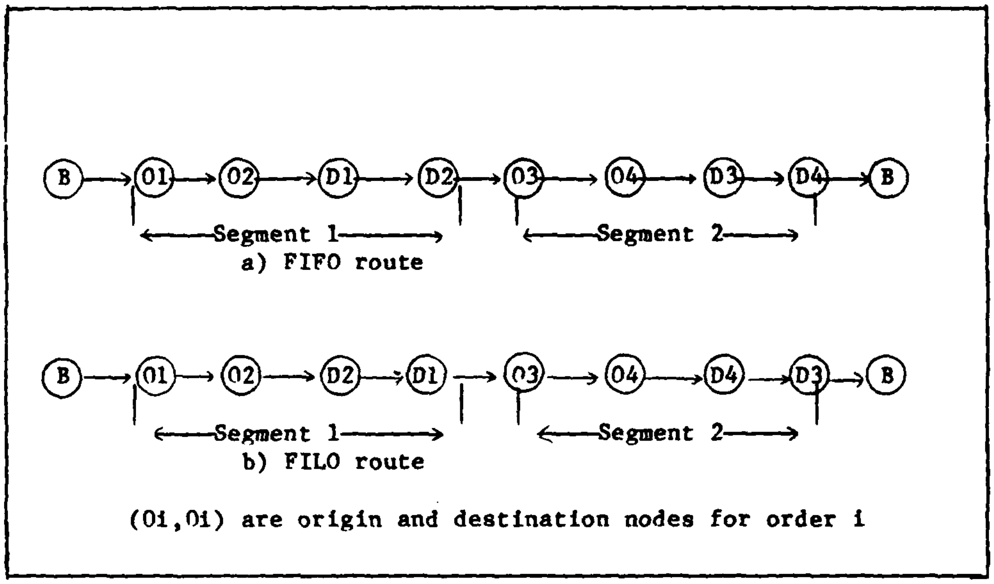

Figure 2. Routes and Segments

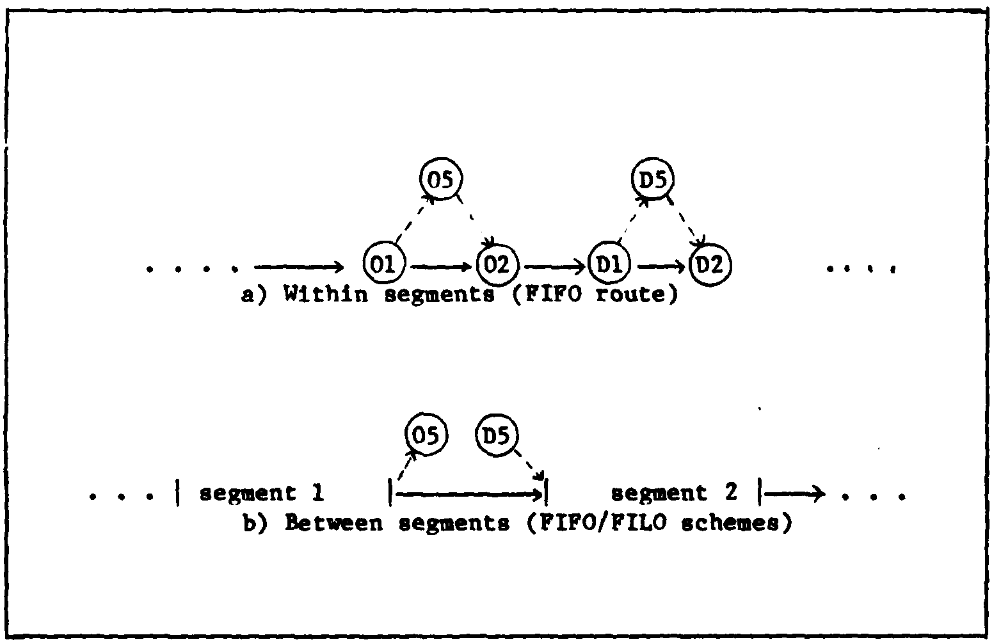

Figure 3. Insertion to a Route

This procedure continues until all orders are scheduled or all vehicles are saturated, i.e. time limits are reached.

Although it may appear that all possible insertions are attempted at each iteration, with the following special procedures the computational time and the number of insertions are actually considerably reduced.

1. Since for each vehicle either a FIFO or a FILO load/unload scheme is used, then for each insertion of a pick-up node the location of the delivery node is uniquely determined.
2. By keeping an insertion table, at each iteration it is sufficient to consider only the insertions for the routes which have been changed at the previous iteration. It is necessary to compute all the insertions for each order at the first iteration. But, in this case the insertions are unique, viz, base-origin-destination-base.

For each feasible insertion the increase in the route duration, S1, is computed first. S1 is computed as:

$$S1 = t(i_1,p) + t(p,i_2) - t(i_1,i_2) + t(j_1,d) + t(d,j_2) - t(j_1,j_2) + 2 \cdot \gamma \; 2\alpha y$$

where

(i_1,i_2) and (j_1,j_2) are the nodes in which nodes (p,d) are inserted respectively.

$t(i,j)$ = travel time between nodes i and j

γ = docking time for the vehicle

α = load/unload time

y = amount of pallets carried by the insertion of the respective order, where y is the minimum of the available capacity or the order size.

S1 could be considered as a measure of performance which measures the increase in the route duration for the respective insertion. However, it does not take into account the number of pallets carried by that insertion. Often the number and size of the orders are so high that it is not possible to schedule all orders with the given vehicle fleet in a single scheduling period. In this case, the unscheduled orders are carried to the next period.

IV. MODEL ENHANCEMENTS

A measure which considered the order size as well as time would help to maximize the number of pallets scheduled or minimize the number of pallets carried over to the next period. One such measure would be to compute the incremental time per pallet (ITPP) moved for each insertion. This figure recognizes the order size as well as the vehicle type. ITPP is computed as:

$$ITPP = S1/y$$

The advantages of using ITPP over S1 are, that it:

1. Utilizes the vehicle capacity more effectively,
2. Allows the scheduling of high pallet orders first,
3. Increases the total number of pallets moved, and
4. Allows the building of new vehicle routes eliminating the need for a least time savings criterion, such as that of [1].

Compared to straddles, the other trucks are less efficient in docking. Thus, handling low pallet orders with these trucks takes more time per pallet than carrying high pallet orders. One way to handle this problem may be to use a two phase approach. In the first phase TR, TT and IT's are scheduled and in the second phase only the ST's are scheduled. With such a scheme and the ITPP criterion, it is hoped that high pallet orders would be scheduled in the first phase and low pallet orders are scheduled in the second.

Another measure of performance would be to divide ITPP by y in order to further encourage the high order schedulings first. Several test runs have been conducted with different alternative criteria and schemes. In Table 7 the results of these runs on the sample data of [1] are tabulated. For the specific sample data, the ITPP criterion with a single phase scheme emerges as the best approach among all criteria and schemes. In Appendix II, the vehicle routes for ITPP criterion and the single phase scheme are given.

Table 7. Insertion Heuristic with Some Alternative Criteria and Schemes

	One Phase Scheme			Two Phase Scheme		
	S1	ITPP	ITPP/y	S1	ITPP	ITPP/y
No. of pallets moved	263	309	307	253	295	302
No. of pallets left over	72	26	28	82	40	33
Total computation time(cpu. sec.)*	16.01	15.17	10.66	12.99	8.26	7.94

(*) Cyber 170/730

V. COMPARISON AND CONCLUSIONS

The insertion heuristic described in the previous section was coded in Fortran IV and the sample data of [1] was run on the Cyber 170. The user can select the evaluation criteria and scheduling scheme in executing the program. In Table 8, the performances of the Navy AVS [1] and the insertion heuristic with ITPP criterion as compared. With the AVS program, it was possible to move 274 pallets out of a 335 pallet order batch. With the insertion heuristic, it was possible to move 309 pallets, a 12.8% increase. Furthermore, the route ending times are less than the respecitve times of AVS.

Additonal improvements over the vehicle routes could be sought by the following procedures.

1) Changing the sequence of segments within a vehicle route,

2) Changing the sequence of nodes within a segment,

3) Changing the sequence of orders within a route,

4) Exchanging orders between vehicles.

Since the order sizes and vehicles capacities are not identical, a procedure incorporating the above improvements would be highly complicated. However, if some of these improvement procedures could be adopted the total number of pallets carried could be further increased.

Table 8. Comparisson of AVS and Insertion Heuristic

Vehicle	AVS		Insertion Heuristic	
	# of pallets moved	Route ending time	# of pallets moved	Route ending time
ST1	32	12:11	106	12:05
ST2	33	10:45	44	12:05
ST3	22	10:53	28	12:03
TR1	91	12:27	67	12:12
TT1	24	13:10	34	12:44
IT1	40	12:44	20	12:13
IT2	26	12:28	20	12:13
Total pallets moved	274	-	309	-
Total pallets not moved	61	-	26	-

VI. *REFERENCES*

[1] Winchell, R., Melton, R. and Natrella, M. (1981), "Automatic Vehicle Scheduling (AVS) Programmer's Instruction Manual for the Burroughs B3500 Computers," Dept. No. DTNSRNC-811018, David W. Taylor Naval Ship Research and Nev-Center, Bethesda, MD (Feb.).

APPENDIX I

SAMPLE ORDER DATA

TOTAL PALLETS CARRIED= 309.0 PALLETS NOT CARRIED= 26.0

ORDERS NOT COMPLETED

ORDER NO.	FROM	TO	PALLETS
2	1605	NWS	6
3	23	NWS	5
4	1	NWS	6
15	67E	16	1
16	67E	23	1
17	67E	61	1
19	67E	1	1
22	67E	84	1
26	1604	1	1
41	1605	23	1
46	1602	23	1
47	1602	645	1

VEHICLE= 7 CAPACITY= 10 TYPE=IT TOTAL VISITS= 24

STOP NO.	LOCATION	ARRIVAL TIME	ORDER DEL/PICK.	PALLETS DEL/PICK	TOTAL LOAD	LEAVING TIME	ORDER STATUS
2	1602	9.00	48	2	2	17.40	
3	1604	19.40	55	3	5	29.50	*SPLIT
4	1604	29.50	24	4	9	36.30	*SPLIT
5	67E	45.30	18	1	10	52.00	
6	647	72.00	18	-1	9	78.70	
7	647	78.70	24	-4	5	85.50	*SPLIT
8	647	85.50	55	-3	2	90.60	*SPLIT
9	647	90.60	48	-2	0	94.00	
10	66E	114.00	54	1	1	120.70	
11	191	129.70	33	1	2	136.40	
12	191	136.40	32	1	3	138.10	
13	1602	140.10	44	2	5	148.50	
14	1605	150.50	37	3	8	160.60	
15	1605	160.60	42	1	9	162.30	
16	1605	162.30	38	1	10	164.00	*SPLIT
17	SM	173.00	38	-1	9	179.70	*SPLIT
18	647	199.70	42	-1	8	206.40	
19	224	215.40	37	-3	5	225.50	
20	224	225.50	44	-2	3	228.90	
21	224	228.90	32	-1	2	230.60	
22	X10	232.60	33	-1	1	239.30	
23	X10	239.30	54	-1	0	241.00	
24	1078	253.00	0	0	0	258.00	

TOTAL PALLETS HANDLED BY THIS VEHICLE= 20.0

VEHICLE= 6 CAPACITY= 10 TYPE=IT TOTAL VISITS= 14

STOP NO.	LOCATION	ARRIVAL TIME	ORDER DEL/PICK.	PALLETS DEL/PICK	TOTAL LOAD	LEAVING TIME	ORDER STATUS
2	191	9.00	34	2	2	17.40	
3	1604	19.40	25	4	6	31.20	*SPLIT
4	23	58.20	25	-4	2	70.00	*SPLIT
5	23	70.00	34	-2	0	73.40	
6	1604	100.40	56	2	2	108.80	
7	1604	108.80	23	4	6	115.60	*SPLIT
8	1603	117.60	27	4	10	129.40	*SPLIT
9	1172	147.40	27	-4	6	159.20	*SPLIT
10	1605	177.20	40	4	10	189.00	*SPLIT
11	X10	212.00	40	-4	6	223.80	*SPLIT
12	224	225.80	23	-4	2	237.60	*SPLIT
13	224	237.60	56	-2	0	241.00	
14	1078	253.00	0	0	0	258.00	

TOTAL PALLETS HANDLED BY THIS VEHICLE= 20.0

****

VEHICLE= 5 CAPACITY= 14 TYPE=TT TOTAL VISITS= 8

STOP NO.	LOCATION	ARRIVAL TIME	ORDER DEL/PICK.	PALLETS DEL/PICK	TOTAL LOAD	LEAVING TIME	ORDER STATUS
2	SM	2.00	1	10	10	24.00	
3	NWS	69.00	1	-10	0	91.00	
4	1	136.00	4	2	2	144.40	*SPLIT
5	1	144.40	5	12	14	164.80	
6	NWS	209.80	5	-12	2	235.20	
7	NWS	235.20	4	-2	0	238.60	*SPLIT
8	1078	283.60	0	0	0	288.60	

TOTAL PALLETS HANDLED BY THIS VEHICLE= 24.0

VEHICLE= 4 CAPACITY= 12 TYPE=TR TOTAL VISITS= 22

STOP NO.	LOCATION	ARRIVAL TIME	ORDER DEL/PICK.	PALLETS DEL/PICK	TOTAL LOAD	LEAVING TIME	ORDER STATUS
2	66E	2.00	51	3	3	6.10	*SPLIT
3	191	13.10	51	-3	0	17.20	*SPLIT
4	1602	19.20	49	12	12	30.50	*SPLIT
5	1507	41.50	49	-12	0	52.80	*SPLIT
6	1502	54.80	36	1	1	57.30	*SPLIT
7	67E	61.30	12	1	2	63.80	*SPLIT
8	67E	63.80	14	10	12	71.80	
9	X10	81.80	14	-10	2	91.50	
10	224	93.50	12	-1	1	96.00	*SPLIT
11	224	96.00	36	-1	0	96.80	*SPLIT
12	67E	106.80	12	2	2	110.10	*SPLIT
13	64W	112.10	9	10	12	121.80	
14	224	131.80	9	-10	2	141.50	
15	224	141.50	12	-2	0	143.10	*SPLIT
16	64W	153.10	10	11	11	163.60	
17	X10	173.60	10	-11	0	184.10	
18	64W	194.10	11	5	5	199.80	*SPLIT
19	1606	206.80	11	-5	0	212.50	*SPLIT
20	1602	214.50	49	12	12	225.80	*SPLIT
21	1507	236.80	49	-12	0	248.10	*SPLIT
22	1078	252.10	0	0	0	253.80	

TOTAL PALLETS HANDLED BY THIS VEHICLE= 67.0

VEHICLE= 3 CAPACITY= 7 TYPE=ST TOTAL VISITS= 10

STOP NO.	LOCATION	ARRIVAL TIME	ORDER DEL/PICK.	PALLETS DEL/PICK	TOTAL LOAD	LEAVING TIME	ORDER STATUS
2	1604	9.00	55	7	7	12.10	*SPLIT
3	647	42.10	55	-7	0	45.20	*SPLIT
4	1604	75.20	24	7	7	78.30	*SPLIT
5	647	108.30	24	-7	0	111.40	*SPLIT
6	1604	141.40	25	7	7	144.50	*SPLIT
7	23	171.50	25	-7	0	174.60	*SPLIT
8	1605	201.60	40	7	7	204.70	*SPLIT
9	X10	227.70	40	-7	0	230.80	*SPLIT
10	1078	242.80	0	0	0	244.50	

TOTAL PALLETS HANDLED BY THIS VEHICLE= 28.0

VEHICLE= 2 CAPACITY= 7 TYPE=ST TOTAL VISITS= 28

STOP NO.	LOCATION	ARRIVAL TIME	ORDER DEL/PICK.	PALLETS DEL/PICK	TOTAL LOAD	LEAVING TIME	ORDER STATUS
2	1603	9.00	27	7	7	12.10	*SPLIT
3	1172	30.10	27	-7	0	33.20	*SPLIT
4	1604	51.20	23	7	7	54.30	*SPLIT
5	224	77.30	23	-7	0	80.40	*SPLIT
6	66E	92.40	50	1	1	94.30	
7	1603	103.30	29	4	5	105.80	*SPLIT
8	1503	118.80	50	-1	4	120.70	
9	1503	120.70	29	-4	0	121.50	*SPLIT
10	1502	123.50	35	2	2	125.60	
11	67E	131.60	20	1	3	133.50	*SPLIT
12	1605	142.50	43	1	4	144.40	
13	1605	144.40	39	1	5	144.60	*SPLIT
14	1621	146.60	35	-2	3	148.70	
15	1621	148.70	20	-1	2	148.90	*SPLIT
16	1621	148.90	43	-1	1	149.10	
17	1606	151.10	39	-1	0	153.00	*SPLIT
18	1605	155.00	38	3	3	157.30	*SPLIT
19	1603	159.30	30	4	7	161.80	*SPLIT
20	SM	170.80	38	-3	4	173.10	*SPLIT
21	1138	175.10	30	-4	0	177.60	*SPLIT
22	1602	186.60	49	6	6	189.50	*SPLIT
23	1507	202.50	49	-6	0	205.40	*SPLIT
24	1502	207.40	36	6	6	210.30	*SPLIT
25	66E	216.30	52	1	7	218.20	
26	224	230.20	36	-6	1	233.10	*SPLIT
27	224	233.10	52	-1	0	233.30	
28	1078	245.30	0	0	0	247.00	

TOTAL PALLETS HANDLED BY THIS VEHICLE= 44.0

43	198	239.40	8	-7	0	242.50	*SPLIT
44	1078	244.50	0	0	0	246.20	

TOTAL PALLETS HANDLED BY THIS VEHICLE= 106.0

VEHICLE= 1 CAPACITY= 7 TYPE=ST TOTAL VISITS= 44

STOP NO.	LOCATION	ARRIVAL TIME	ORDER DEL/PICK.	PALLETS DEL/PICK	TOTAL LOAD	LEAVING TIME	ORDER STATUS
2	66E	2.00	51	7	7	5.10	*SPLIT
3	191	14.10	51	-7	0	17.20	*SPLIT
4	1602	19.20	45	7	7	22.30	
5	SM	31.30	45	-7	0	34.40	
6	67E	36.40	20	7	7	39.50	*SPLIT
7	1621	48.50	20	-7	0	51.60	*SPLIT
8	1603	53.60	29	7	7	56.70	*SPLIT
9	1503	69.70	29	-7	0	72.80	*SPLIT
10	1603	85.80	30	7	7	88.90	*SPLIT
11	1138	97.90	30	-7	0	101.00	*SPLIT
12	67W	103.00	58	1	1	104.90	
13	66E	106.90	53	1	2	108.80	
14	67E	110.80	13	4	6	113.30	*SPLIT
15	67E	113.30	21	1	7	113.50	
16	SM	115.50	58	-1	6	117.40	
17	SM	117.40	53	-1	5	117.60	
18	SM	117.60	13	-4	1	118.40	*SPLIT
19	49	120.40	21	-1	0	122.30	
20	67E	124.30	13	7	7	127.40	*SPLIT
21	SM	129.40	13	-7	0	132.50	*SPLIT
22	64W	134.50	11	7	7	137.60	*SPLIT
23	1606	146.60	11	-7	0	149.70	*SPLIT
24	1603	151.70	28	4	4	154.20	*SPLIT
25	1605	156.20	28	-4	0	158.70	*SPLIT
26	1605	158.70	39	2	2	159.10	*SPLIT
27	1603	161.10	31	5	7	163.80	
28	1606	165.80	39	-2	5	167.90	*SPLIT
29	1606	167.90	31	-5	0	168.90	
30	1603	170.90	28	7	7	174.00	*SPLIT
31	1605	176.00	28	-7	0	179.10	*SPLIT
32	1605	179.10	38	7	7	180.50	*SPLIT
33	SM	189.50	38	-7	0	192.60	*SPLIT
34	64W	194.60	8	5	5	197.30	*SPLIT
35	198	199.30	8	-5	0	202.00	*SPLIT
36	198	202.00	7	6	6	203.20	
37	SM	205.20	57	1	7	207.10	
38	1172	216.10	7	-6	1	219.00	
39	1172	219.00	57	-1	0	219.20	
40	1172	219.20	6	6	6	220.40	
41	198	229.40	6	-6	0	232.30	
42	64W	234.30	8	7	7	237.40	*SPLIT

VEHICLE DATA

VEHICLE	TYPE	CAPACITY	TIME LIMIT	MIN. CAP.	DOCK. TIME	LOAD TIME
1	ST	7	240.0	5	1.70	.20
2	ST	7	240.0	5	1.70	.20
3	ST	7	240.0	5	1.70	.20
4	TR	12	240.0	8	1.70	.80
5	TT	14	240.0	14	5.00	1.70
6	IT	10	240.0	6	5.00	1.70
7	IT	10	240.0	6	5.00	1.70

SCHEDULE COMPLETED IN 13.75 CPU. SEC.S

APPENDIX II

VEHICLE SCHEDULES FOR THE INSERTION HEURISTIC

(ITPP Criterion with Single Phase Scheme)

44	1602	224	2
45	1602	SM	7
46	1602	23	1
47	1602	646	1
48	1602	647	2
49	1602	1507	30
50	66E	1503	1
51	66E	191	10
52	66E	224	1
53	66E	SM	1
54	66E	X10	1
55	1604	647	10
56	1604	224	2
57	SM	1172	1
58	67W	SM	1

TOTAL NO. OF PALLETS TO BE HANDLED= 335

ORDER DATA

ORDER NO.	FROM	TO	PALLETS
1	SM	NWS	10
2	1605	NWS	6
3	23	NWS	5
4	1	NWS	8
5	1	NWS	12
6	1172	198	6
7	198	1172	6
8	64W	198	12
9	64W	224	10
10	64W	X10	11
11	64W	1606	12
12	67E	224	3
13	67E	SM	11
14	67E	X10	10
15	67E	16	1
16	67E	23	1
17	67E	61	1
18	67E	647	1
19	67E	1	1
20	67E	1621	8
21	67E	49	1
22	67E	84	1
23	1604	224	11
24	1604	647	11
25	1604	23	11
26	1604	1	1
27	1603	1172	11
28	1603	1605	11
29	1603	1503	11
30	1603	1133	11
31	1603	1606	5
32	191	224	1
33	191	X10	1
34	191	23	2
35	1502	1621	2
36	1502	224	7
37	1605	224	3
38	1605	SM	11
39	1605	1606	3
40	1605	X10	11
41	1605	23	1
42	1605	647	1
43	1605	1621	1

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