

# Supplementary Material for Efficient Task Allocation in Smart Warehouses with Multi-delivery Stations and Heterogeneous Robots

George S. Oliveira<sup>1\*</sup>, Patricia D. M. Plentz<sup>1†</sup>, Jônata T. Carvalho<sup>1†</sup> and Juha Röning<sup>2†</sup>

<sup>1\*</sup>Department of Informatics and Statistics (INE), Federal University of Santa Catarina, Campus Universitário Reitor João David Ferreira Lima, Trindade, Florianópolis, 88040-900, Santa Catarina, Brazil.

<sup>2\*</sup>Biomimetics and Intelligent Systems Group - BISG, Finland, University of Oulu, Oulu, , Finland.

\*Corresponding author(s). E-mail(s):

[george.oliveira@posgrad.ufsc.br](mailto:george.oliveira@posgrad.ufsc.br);

Contributing authors: [patricia.plentz@ufsc.br](mailto:patricia.plentz@ufsc.br);

[jonata.tyska@ufsc.br](mailto:jonata.tyska@ufsc.br); [juha.roning@oulu.fi](mailto:juha.roning@oulu.fi);

<sup>†</sup>These authors contributed equally to this work.

# 1 Introduction

## 2 Related Works

## 3 Problem Formulation

## 4 Cost Estimator Based on Variable Load Capacity

## 5 Algorithm Design

## 6 Datasets

Table 1 shows the list of real robots that make up instances of heterogeneous fleet datasets (RMT and SMT), grouped by their respective maximum load capacity. Robots are selected based on the Box-Muller Algorithm for randomization in Normal Distribution with mean  $\mu = 17$  and standard deviation  $\sigma = 578$ . The mean refers to the smallest load capacity among all robots, and the standard deviation was chosen to generate random values that vary between the robots' capacities. In order to build instances RMT and SMT datasets, robots were selected as follows:

1. Generates a random value  $\varrho$  by Box-Muller Algorithm with  $\mu = 17$  and  $\sigma = 578$ .
2. Ignores values less than zero and greater than 1500 (largest capacity).
3. Select a robot from the Table 1 based on the following rules:
  - (a) If  $\varrho \leq 18$ , then select any robot from Group A;
  - (b) If  $18 < \varrho \leq 55$ , then select any robot from Group A or B;
  - (c) If  $55 < \varrho \leq 80$ , then select any robot from Group A, B or C;
  - (d) If  $80 < \varrho \leq 100$ , then select any robot from Group A to D;
  - (e) If  $100 < \varrho \leq 200$ , then select any robot from Group A to E;
  - (f) If  $200 < \varrho \leq 500$ , then select any robot from Group A to F;
  - (g) If  $500 < \varrho \leq 750$ , then select any robot from Group A to G;
  - (h) If  $\varrho > 750$ , then select any robot;

**Table 1:** List of robots that make up RMT and SMT instances. Each robot belongs to the group defined by its load capacity.

Robot Name	Load Capacity (kg)	Group	Traffic Speed (m/s)
Adept Pioneer 3-DX	17	Group A	1.2
InVia Picker Robot	18	Group A	2.2
Locus Bot	45	Group B	1.1
CajaRobotics Cart Robot	55	Group B	2
Omron LD-60	60	Group C	1.8
Matthews AMR	70	Group C	1.8

*Continues on the next page*

Table 1 – *Continued from the previous page*

Robot Name	Load Capacity (kg)	Group	Traffic Speed (m/s)
FetchRobotics HMIShelf	78	Group C	1.5
FetchRobotics RollerTop	80	Group C	1.5
Omron LD-90	90	Group D	1.35
Otto-100	100	Group D	2
Pollux MiR100	100	Group D	1.5
Pollux MiR200	200	Group E	1.1
Magazino TORU	235	Group E	1.5
Conveyco Stacker-Bot	250	Group E	1.33
Omron LD-250	250	Group E	1.2
Pollux MiR250	250	Group E	2
CajaRobotics Lift Robot	300	Group E	1.5
IAMRobotics Bolt	300	Group E	2
FetchRobotics Freight500	500	Group F	1.5
Pollux MiR500	500	Group F	2
Otto-750	750	Group G	2
Pollux MiR1000	1000	Group G	1.2
FetchRobotics Freight1500	1500	Group H	1.5
Omron HD-1500	1500	Group H	1.8
Otto-1500	1500	Group H	2

## 7 Evaluation

**Table 2:** All test results for SMT instances (HFMDVRP-DV) by DoNe-CPTA and a-nCAR

Instance Name	a-nCAR			DoNe-CPTA			Performance DoNe-CPTA vs a-nCAR				
	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time		
SMT-t101-r25-d4	25	24745.8	0.6	24	15679.2	0.1	4%	37%	89%		
SMT-t106-r14-d4	14	11898.5	0.5	10	8310.5	0.1	29%	30%	82%		
SMT-t110-r13-d4	13	14863.4	0.5	13	10663.6	0.1	0%	28%	87%		
SMT-t115-r10-d4	10	16445.0	0.9	10	11254.8	0.1	0%	32%	92%		
SMT-t120-r6-d4	6	11543.5	0.6	6	8919.8	0.1	0%	23%	88%		
SMT-t125-r30-d4	30	27077.9	1.4	27	17863.9	0.1	10%	34%	93%		
SMT-t129-r18-d4	18	20020.5	1.0	18	13832.2	0.1	0%	31%	92%		
SMT-t134-r13-d4	13	11109.6	1.2	11	6978.7	0.1	15%	37%	92%		
SMT-t139-r10-d4	10	15001.1	0.9	10	11126.5	0.1	0%	26%	90%		
SMT-t143-r7-d4	7	13210.2	1.2	7	9712.5	0.1	0%	26%	92%		
SMT-t148-r46-d4	46	28332.6	2.8	42	20067.9	0.1	9%	29%	96%		
SMT-t153-r22-d4	22	22914.9	2.4	18	15660.5	0.1	18%	32%	94%		
SMT-t157-r13-d4	13	12720.5	1.3	12	9864.1	0.2	8%	22%	87%		
SMT-t162-r11-d4	11	14765.9	1.4	11	11077.4	0.1	0%	25%	92%		
SMT-t167-r10-d4	10	15729.6	1.5	10	12128.5	0.1	0%	23%	93%		
SMT-t172-r51-d4	51	39980.2	4.9	48	24300.9	0.2	6%	39%	97%		
SMT-t176-r26-d4	26	30778.3	3.9	26	18857.4	0.1	0%	39%	97%		
SMT-t181-r23-d4	23	16839.4	2.6	21	13045.8	0.2	9%	23%	91%		
SMT-t186-r15-d4	15	18359.2	2.3	15	13626.2	0.1	0%	26%	94%		
SMT-t190-r8-d4	8	11418.3	2.3	7	8185.1	0.2	13%	28%	93%		
SMT-t195-r51-d4	51	42479.6	6.0	48	25261.0	0.2	6%	41%	97%		
SMT-t200-r36-d4	36	30052.2	5.1	29	18237.8	0.2	19%	39%	95%		
SMT-t204-r19-d4	19	20058.1	3.3	19	14704.4	0.2	0%	27%	95%		
SMT-t209-r16-d4	16	20294.1	3.4	16	15025.3	0.2	0%	26%	95%		
SMT-t214-r11-d4	11	11326.4	3.7	9	8797.9	0.2	18%	22%	95%		
SMT-t219-r73-d4	73	44061.4	11.8	58	32672.9	0.6	21%	26%	95%		
SMT-t223-r34-d4	34	33067.8	7.4	33	22680.0	0.2	3%	31%	97%		
SMT-t228-r23-d4	23	26358.4	8.4	21	17728.7	0.2	9%	33%	98%		
SMT-t233-r16-d4	16	20551.5	7.9	16	14401.8	0.2	0%	30%	98%		
SMT-t237-r14-d4	14	20267.4	4.3	14	14709.1	0.2	0%	27%	96%		
SMT-t242-r48-d4	48	35828.1	12.0	47	25193.4	0.2	2%	30%	98%		
SMT-t247-r50-d5	48	38381.6	13.9	31	26547.0	0.5	35%	31%	96%		
SMT-t251-r28-d5	28	24660.9	7.8	27	17324.9	0.3	4%	30%	96%		
Continues on the next page											

*Continues on the next page*

4 *Supplementary Material*Table 2 – *Continued from the previous page*

Instance Name	a-nCAR			DoNe-CPTA			Performance DoNe-CPTA vs a-nCAR		
	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time
SMT-t256-r16-d5	16	18547.4	6.3	16	12988.2	0.2	0%	30%	96%
SMT-t261-r13-d5	13	21228.5	6.7	13	14101.3	0.2	0%	34%	97%
SMT-t266-r58-d5	58	35182.7	17.3	52	24678.4	0.6	10%	30%	96%
SMT-t270-r35-d5	35	29887.7	11.8	35	21344.9	0.4	0%	29%	97%
SMT-t275-r28-d5	28	18687.5	9.8	25	12279.6	0.5	11%	34%	95%
SMT-t280-r17-d5	17	26944.7	15.3	17	17744.7	0.2	0%	34%	99%
SMT-t284-r15-d5	14	18045.5	8.4	14	12087.9	0.2	0%	33%	97%
SMT-t289-r60-d5	60	53288.5	25.5	57	29790.0	0.3	5%	44%	99%
SMT-t294-r50-d5	50	45252.5	20.8	49	27080.7	0.3	2%	40%	99%
SMT-t298-r31-d5	31	33599.6	15.6	31	21030.0	0.2	0%	37%	98%
SMT-t303-r21-d5	20	22810.2	13.0	20	14795.7	0.3	0%	35%	98%
SMT-t308-r13-d5	13	23151.4	18.5	13	16093.7	0.2	0%	30%	99%
SMT-t313-r71-d5	71	60607.0	36.0	67	35039.7	0.5	6%	42%	99%
SMT-t317-r53-d5	53	34106.7	24.4	42	23442.1	2.4	21%	31%	90%
SMT-t322-r28-d5	28	27856.4	16.2	28	19747.0	0.4	0%	29%	98%
SMT-t327-r20-d5	20	23835.0	14.0	20	15808.6	0.3	0%	34%	98%
SMT-t331-r15-d5	14	22862.5	12.1	15	16746.7	0.4	-7%	27%	97%
SMT-t336-r84-d5	84	70404.9	52.4	83	39557.5	0.5	1%	44%	99%
SMT-t344-r43-d5	43	35596.1	28.1	43	25375.5	0.6	0%	29%	98%
SMT-t351-r40-d5	40	26965.2	29.9	32	16183.1	0.4	20%	40%	99%
SMT-t359-r29-d5	29	34614.5	24.5	29	21911.8	0.3	0%	37%	99%
SMT-t367-r17-d5	17	20918.3	31.2	16	14607.0	0.3	6%	30%	99%
SMT-t376-r94-d5	94	51880.7	71.9	85	37361.1	3.4	10%	28%	95%
SMT-t384-r52-d5	52	40874.3	44.9	52	28349.4	0.8	0%	31%	98%
SMT-t393-r38-d5	38	34667.7	36.5	37	24489.2	1.0	3%	29%	97%
SMT-t401-r29-d5	29	30510.9	48.9	26	19658.7	0.6	10%	36%	99%
SMT-t411-r19-d5	18	23850.5	43.9	16	15208.6	0.4	11%	36%	99%
SMT-t420-r130-d5	130	67073.4	133.0	117	51159.0	1.8	10%	24%	99%
SMT-t429-r61-d5	61	42578.3	67.9	61	30301.5	1.2	0%	29%	98%
SMT-t439-r37-d5	36	33029.9	45.2	37	23877.6	1.5	-3%	28%	97%
SMT-t449-r29-d5	29	33590.8	49.8	29	21874.9	0.4	0%	35%	99%
SMT-t459-r26-d5	26	26401.5	57.2	22	15589.6	0.6	15%	41%	99%
SMT-t469-r138-d5	138	70181.3	193.4	121	53533.0	4.5	12%	24%	98%
SMT-t480-r70-d5	70	45394.1	110.3	64	32977.2	2.6	9%	27%	98%
SMT-t491-r59-d5	59	46319.8	108.3	58	28668.3	0.8	2%	38%	99%
SMT-t502-r39-d5	38	30046.8	70.3	32	20401.3	4.3	16%	32%	94%
SMT-t513-r21-d5	21	31505.7	56.5	21	20927.1	0.6	0%	34%	99%
SMT-t524-r153-d5	145	100584.3	260.4	151	56719.8	4.6	-4%	44%	98%
SMT-t536-r96-d5	96	77836.3	215.4	75	42587.5	2.6	22%	45%	99%
SMT-t548-r50-d5	49	41984.4	117.8	50	29866.9	2.6	-2%	29%	98%
SMT-t561-r42-d5	42	45837.4	123.0	42	28596.1	0.7	0%	38%	99%
SMT-t573-r30-d5	30	27100.9	153.2	22	15728.3	1.1	27%	42%	99%
SMT-t586-r159-d5	159	86361.7	438.8	133	63296.7	10.5	16%	27%	98%
SMT-t599-r92-d5	92	59459.6	278.8	92	42585.9	4.3	0%	28%	98%
SMT-t613-r62-d5	62	52765.3	222.1	62	32326.3	0.9	0%	39%	100%
SMT-t627-r43-d5	43	36547.1	156.8	37	23896.6	3.4	14%	35%	98%
SMT-t641-r35-d5	35	39544.2	146.7	35	27744.5	1.7	0%	30%	99%
SMT-t655-r131-d5	131	95529.5	493.5	74	64081.7	56.2	44%	33%	89%
SMT-t670-r130-d6	127	96610.6	598.1	128	56199.3	5.6	-1%	42%	99%
SMT-t685-r75-d6	75	57823.8	468.5	74	33373.9	1.5	1%	42%	100%
SMT-t701-r44-d6	44	48867.9	244.3	44	29581.9	1.1	0%	39%	100%
SMT-t716-r35-d6	35	32002.2	210.3	26	18798.6	1.5	26%	41%	99%
SMT-t733-r159-d6	159	82975.0	915.6	156	57317.4	5.6	2%	31%	99%
SMT-t749-r98-d6	98	69727.4	571.0	84	39689.5	2.4	14%	43%	100%
SMT-t766-r71-d6	71	67154.1	767.0	71	39595.3	2.1	0%	41%	100%
SMT-t783-r48-d6	48	48175.0	479.0	48	28904.6	1.1	0%	40%	100%
SMT-t801-r40-d6	39	42794.2	297.7	40	28875.6	4.1	-3%	33%	99%
SMT-t819-r171-d6	171	88061.3	1244.1	136	62998.0	43.9	20%	28%	96%
SMT-t837-r142-d6	142	80151.8	1139.6	139	58901.0	22.9	2%	27%	98%
SMT-t856-r95-d6	95	63240.9	783.0	94	47971.9	24.9	1%	24%	97%
SMT-t876-r59-d6	59	48541.7	592.4	51	29790.9	2.7	14%	39%	100%
SMT-t895-r37-d6	37	50202.6	410.2	37	31606.9	1.7	0%	37%	100%
SMT-t916-r207-d6	207	101892.8	2162.2	181	73197.7	50.3	13%	28%	98%
SMT-t936-r151-d6	151	112164.5	1926.3	150	63291.7	13.3	1%	44%	99%
SMT-t957-r87-d6	87	60502.2	1023.6	86	40531.6	27.0	1%	33%	97%
SMT-t979-r58-d6	58	52015.7	1012.5	51	31138.0	5.9	12%	40%	99%
SMT-t1001-r43-d6	43	56497.9	714.0	43	34869.6	1.5	0%	38%	100%
AVERAGE:							6%	33%	96%

Table 3: All test results for WMT instances (MDVRP-DV) by DoNe-CPTA and a-nCAR

Instance Name	a-nCAR			DoNe-CPTA			Performance DoNe-CPTA vs a-nCAR		
	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time
WMT-t101-r25-d4	25	33681.5	0.5	25	24318.0	0.1	0%	28%	88%
WMT-t106-r14-d4	14	19521.3	0.4	10	13911.8	0.1	29%	29%	81%
WMT-t110-r13-d4	13	23125.7	0.5	13	17441.5	0.1	0%	25%	86%

*Continues on the next page*

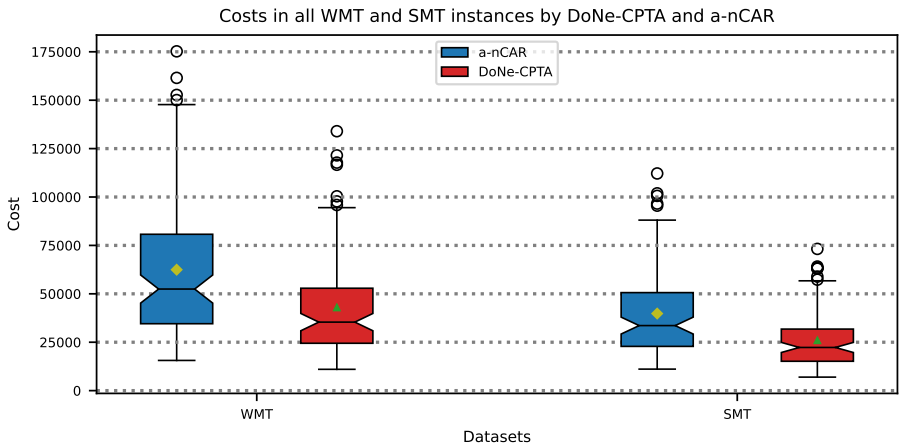
Table 3 – Continued from the previous page

Instance Name	a-nCAR			DoNe-CPTA			Performance DoNe-CPTA vs a-nCAR		
	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time
WMT-t115-r10-d4	10	22765.8	0.8	10	17045.6	0.1	0%	25%	91%
WMT-t120-r6-d4	6	19293.1	0.5	6	14421.5	0.1	0%	25%	86%
WMT-t125-r30-d4	30	38098.9	1.2	28	28931.0	0.1	7%	24%	92%
WMT-t129-r18-d4	18	28913.9	0.9	18	20620.0	0.1	0%	29%	90%
WMT-t134-r13-d4	13	15989.5	1.2	11	11006.0	0.1	15%	31%	92%
WMT-t139-r10-d4	10	23998.5	0.8	10	17929.0	0.1	0%	25%	90%
WMT-t143-r7-d4	7	22829.5	1.1	7	16295.8	0.1	0%	29%	92%
WMT-t148-r46-d4	46	47423.6	2.6	45	33854.1	0.1	2%	29%	95%
WMT-t153-r22-d4	22	36144.6	2.1	19	26289.1	0.1	14%	27%	94%
WMT-t157-r13-d4	13	20511.3	1.2	13	15393.5	0.1	0%	25%	88%
WMT-t162-r11-d4	11	25351.5	1.3	11	18162.1	0.1	0%	28%	92%
WMT-t167-r10-d4	10	25897.8	1.4	10	19961.5	0.1	0%	23%	93%
WMT-t172-r51-d4	51	60132.6	4.5	50	39848.8	0.2	2%	34%	96%
WMT-t176-r26-d4	26	47729.0	3.2	26	29059.8	0.1	0%	39%	96%
WMT-t181-r23-d4	23	27042.8	2.4	21	20037.9	0.2	9%	26%	92%
WMT-t186-r15-d4	15	30555.2	2.2	15	21540.5	0.1	0%	30%	95%
WMT-t190-r8-d4	8	15593.8	2.2	8	13188.9	0.1	0%	15%	93%
WMT-t195-r51-d4	51	59795.1	5.9	49	40103.9	0.2	4%	33%	97%
WMT-t200-r36-d4	36	41617.2	5.1	31	30449.5	0.2	14%	27%	95%
WMT-t204-r19-d4	19	32224.7	3.2	19	23294.2	0.2	0%	28%	95%
WMT-t209-r16-d4	16	33642.0	3.3	16	24506.1	0.1	0%	27%	96%
WMT-t214-r11-d4	11	19056.3	3.5	9	15822.1	0.2	18%	17%	95%
WMT-t219-r73-d4	73	64161.5	10.2	73	53845.2	0.6	0%	16%	94%
WMT-t223-r34-d4	34	47899.2	6.9	34	34333.2	0.2	0%	28%	97%
WMT-t228-r23-d4	23	39424.7	6.8	22	27487.8	0.2	4%	30%	97%
WMT-t233-r16-d4	16	36021.0	7.3	16	24007.9	0.2	0%	33%	98%
WMT-t237-r14-d4	14	31930.4	4.0	14	23864.8	0.2	0%	25%	96%
WMT-t242-r48-d4	48	58175.5	11.1	48	41227.0	0.2	0%	29%	98%
WMT-t247-r50-d5	50	59858.0	11.0	36	48621.6	0.5	28%	19%	95%
WMT-t251-r28-d5	28	40957.9	7.6	27	27581.0	0.3	4%	33%	96%
WMT-t256-r16-d5	16	30865.2	5.8	16	20924.7	0.2	0%	32%	96%
WMT-t261-r13-d5	13	32098.5	6.5	13	23387.9	0.2	0%	27%	97%
WMT-t266-r58-d5	58	56079.7	16.7	57	42381.0	0.5	2%	24%	97%
WMT-t270-r35-d5	35	45280.8	11.5	35	34190.7	0.3	0%	24%	97%
WMT-t275-r28-d5	28	30932.0	9.1	25	19799.2	0.4	11%	36%	96%
WMT-t280-r17-d5	17	37982.4	15.0	17	27757.1	0.2	0%	27%	99%
WMT-t284-r15-d5	15	25669.2	8.1	15	18786.5	0.2	0%	27%	97%
WMT-t289-r60-d5	60	80466.3	23.1	59	47029.6	0.4	2%	42%	98%
WMT-t294-r50-d5	50	62739.6	19.1	50	41078.9	0.3	0%	35%	98%
WMT-t298-r31-d5	31	47942.1	15.0	31	32003.5	0.3	0%	33%	98%
WMT-t303-r21-d5	21	37129.6	13.0	20	24992.0	0.3	5%	33%	98%
WMT-t308-r13-d5	13	34318.5	17.2	13	24802.8	0.2	0%	28%	99%
WMT-t313-r71-d5	71	92179.2	32.6	69	55599.3	0.5	3%	40%	98%
WMT-t317-r53-d5	53	52792.7	23.0	47	41638.7	1.7	11%	21%	93%
WMT-t322-r28-d5	28	45619.8	16.2	28	31251.1	0.3	0%	31%	98%
WMT-t327-r20-d5	20	39262.4	13.4	20	25603.3	0.3	0%	35%	98%
WMT-t331-r15-d5	15	36879.6	11.2	15	26875.2	0.3	0%	27%	98%
WMT-t336-r84-d5	84	105611.3	48.6	84	62264.3	0.6	0%	41%	99%
WMT-t344-r43-d5	43	55986.7	27.5	43	40483.3	0.6	0%	28%	98%
WMT-t351-r40-d5	40	45457.3	28.5	32	28124.0	0.5	20%	38%	98%
WMT-t359-r29-d5	29	49088.9	23.3	29	33148.0	0.3	0%	32%	99%
WMT-t367-r17-d5	17	30680.2	29.9	17	22317.3	0.3	0%	27%	99%
WMT-t376-r94-d5	94	76215.6	62.5	94	60687.8	2.4	0%	20%	96%
WMT-t384-r52-d5	52	63508.1	45.2	52	45816.1	0.7	0%	28%	98%
WMT-t393-r38-d5	38	57514.3	36.5	38	39668.2	0.8	0%	31%	98%
WMT-t401-r29-d5	29	52136.9	46.4	26	34653.8	0.5	10%	34%	99%
WMT-t411-r19-d5	19	34639.7	41.1	16	23483.5	0.5	16%	32%	99%
WMT-t420-r130-d5	130	113279.5	130.4	125	89590.2	2.1	4%	21%	98%
WMT-t429-r61-d5	61	67698.2	71.1	61	49133.9	1.1	0%	27%	98%
WMT-t439-r37-d5	37	53012.0	45.2	37	37394.7	1.1	0%	29%	98%
WMT-t449-r29-d5	29	56250.0	47.4	29	36118.9	0.4	0%	36%	99%
WMT-t459-r26-d5	26	42382.5	55.5	23	26982.9	0.6	12%	36%	99%
WMT-t469-r138-d5	138	114667.7	197.2	138	95869.2	6.1	0%	16%	97%
WMT-t480-r70-d5	70	72429.3	109.5	65	53345.8	2.3	7%	26%	98%
WMT-t491-r59-d5	59	79468.4	101.5	58	48826.1	0.9	2%	39%	99%
WMT-t502-r39-d5	39	48234.7	70.0	33	32984.0	3.9	15%	32%	94%
WMT-t513-r21-d5	21	45893.7	55.3	21	32163.3	0.6	0%	30%	99%
WMT-t524-r153-d5	153	152723.1	208.2	153	89514.1	7.1	0%	41%	97%
WMT-t536-r96-d5	96	126189.1	205.7	82	72005.0	2.8	15%	43%	99%
WMT-t548-r50-d5	50	67355.5	111.4	50	47547.1	1.8	0%	29%	98%
WMT-t561-r42-d5	42	67627.3	119.5	42	43700.3	0.9	0%	35%	99%
WMT-t573-r30-d5	30	39565.2	149.0	22	25605.2	1.3	27%	35%	99%
WMT-t586-r159-d5	159	140505.6	442.5	155	116650.9	11.5	3%	17%	97%
WMT-t599-r92-d5	92	93028.3	277.6	92	69285.3	4.0	0%	26%	99%
WMT-t613-r62-d5	62	91828.3	210.2	62	54400.6	1.1	0%	41%	99%
WMT-t627-r43-d5	43	59254.0	160.4	37	38492.4	3.3	14%	35%	98%
WMT-t641-r35-d5	35	63368.8	142.7	35	43722.2	1.7	0%	31%	99%
WMT-t655-r131-d5	131	150065.6	446.4	92	121489.8	27.5	30%	19%	94%
WMT-t670-r130-d6	130	147731.9	494.0	130	89344.3	9.6	0%	40%	98%
WMT-t685-r75-d6	75	103078.0	448.8	75	57298.2	1.9	0%	44%	100%
WMT-t701-r44-d6	44	69905.5	234.2	44	44324.9	1.5	0%	37%	99%
WMT-t716-r35-d6	35	50985.6	210.3	26	31848.9	1.8	26%	38%	99%
WMT-t733-r159-d6	159	133043.4	862.7	158	94504.0	5.5	1%	29%	99%

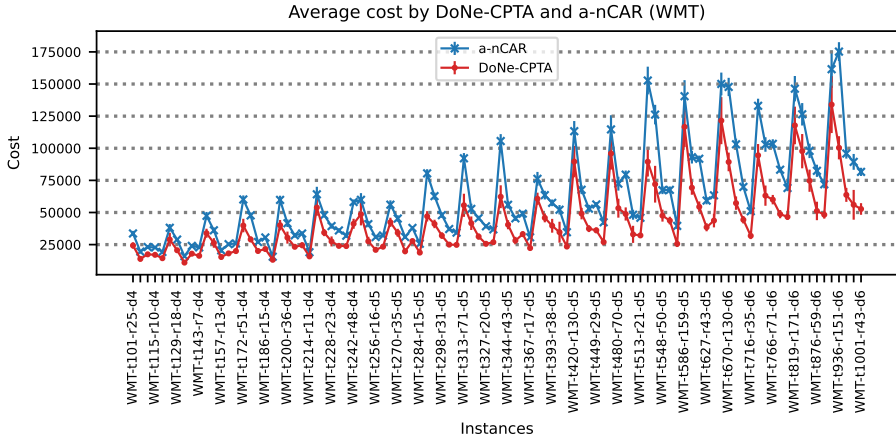
Continues on the next page

6 *Supplementary Material*Table 3 – *Continued from the previous page*

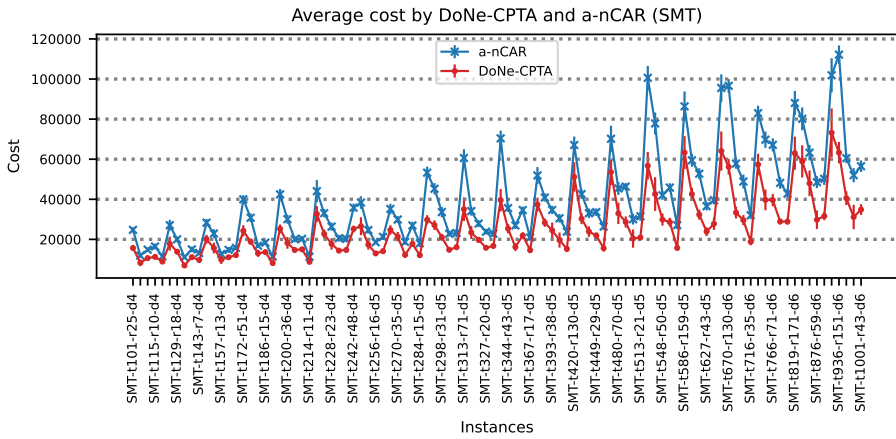
Instance Name	a-nCAR			DoNe-CPTA			Performance DoNe-CPTA vs a-nCAR		
	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time
WMT-t749-r98-d6	98	102925.1	545.8	88	63110.9	3.3	10%	39%	99%
WMT-t766-r71-d6	71	103430.2	633.7	71	59998.9	4.2	0%	42%	99%
WMT-t783-r48-d6	48	83286.4	467.2	48	48732.4	1.6	0%	41%	100%
WMT-t801-r40-d6	40	69067.2	293.7	40	46615.1	2.8	0%	33%	99%
WMT-t819-r171-d6	171	146369.1	1279.3	154	117769.7	27.0	10%	20%	98%
WMT-t837-r142-d6	142	126433.6	1126.6	141	97730.4	16.8	1%	23%	99%
WMT-t856-r95-d6	95	97941.2	744.4	95	74747.8	18.6	0%	24%	98%
WMT-t876-r59-d6	59	82462.1	597.8	52	51201.0	3.3	12%	38%	99%
WMT-t895-r37-d6	37	71940.9	410.8	37	48266.7	2.5	0%	33%	99%
WMT-t916-r207-d6	207	161533.0	2105.6	205	133980.4	36.6	1%	17%	98%
WMT-t936-r151-d6	151	175233.2	1509.6	151	100367.3	20.7	0%	43%	99%
WMT-t957-r87-d6	87	95904.5	959.4	87	63712.3	19.8	0%	34%	98%
WMT-t979-r58-d6	58	89398.6	993.2	52	55985.2	6.3	10%	37%	99%
WMT-t1001-r43-d6	43	81617.6	697.1	43	52737.0	2.4	0%	35%	100%
AVERAGE:							4%	30%	96%

**Figure 1** Overview of the route costs by DoNe-CPTA and a-nCAR both running SMT and WMT instances.**Table 4** Mann-Whitney U test results for route costs by DoNe-CPTA and a-nCAR on SMT and WMT. Skewed right data by Shapiro Wilk.

Dataset	Significance Level	p-value	Result	Common-Language Effect Size
WMT	0.05	$2.624 \times 10^{-5}$	Reject $H_0$	33%
SMT	0.05	$2.933 \times 10^{-6}$	Reject $H_0$	31%



**Figure 2** Route costs by DoNe-CPTA and a-nCAR both running WMT instances.



**Figure 3** Route costs by DoNe-CPTA and a-nCAR both running SMT instances.

**Table 5** Mann-Whitney U test results for execution time by DoNe-CPTA and a-nCAR on SMT and WMT. Skewed right data by Shapiro Wilk.

Dataset	Significance Level	p-value	Result	Common-Language Effect Size
WMT	0.05	$9.992 \times 10^{-16}$	Reject $H_0$	9.6%
SMT	0.05	0	Reject $H_0$	8.9%

**Table 7:** All test results for RMT instances (HFVRP) by DoNe-CPTA and a-nCAR

Instance Name	a-nCAR		DoNe-CPTA		Performance DoNe-CPTA vs a-nCAR				
	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time
RMT-t101-r25-d1	25	28554.6	0.6	22	30337.8	0.1	12%	-6%	85%

*Continues on the next page*

8 *Supplementary Material*Table 7 – *Continued from the previous page*

Instance Name	a-nCAR			DoNe-CPTA			Performance DoNe-CPTA vs a-nCAR		
	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time
RMT-t106-r14-d1	14	21900.2	0.5	12	21508.9	0.1	14%	2%	74%
RMT-t110-r13-d1	13	14552.3	0.5	12	15224.4	0.1	8%	-5%	82%
RMT-t115-r10-d1	10	15466.6	0.9	10	14606.5	0.1	0%	6%	91%
RMT-t120-r6-d1	6	13683.9	0.6	6	14256.6	0.1	0%	-4%	82%
RMT-t125-r30-d1	30	53906.7	1.4	25	54690.8	0.2	17%	-1%	89%
RMT-t129-r18-d1	18	29787.3	1.0	14	30157.8	0.1	22%	-1%	87%
RMT-t134-r13-d1	13	11414.5	1.2	11	12174.9	0.1	15%	-7%	89%
RMT-t139-r10-d1	10	14650.5	0.9	10	14416.1	0.1	0%	2%	88%
RMT-t143-r7-d1	7	15802.8	1.2	7	16373.3	0.1	0%	-4%	90%
RMT-t148-r46-d1	46	34737.5	2.8	37	40159.6	0.2	20%	-16%	92%
RMT-t153-r22-d1	22	22353.5	2.4	18	21135.3	0.2	18%	5%	93%
RMT-t157-r13-d1	13	14358.0	1.3	11	13983.0	0.2	15%	3%	82%
RMT-t162-r11-d1	11	14275.4	1.4	10	14015.5	0.1	9%	2%	90%
RMT-t167-r10-d1	10	19962.6	1.6	9	19927.6	0.2	10%	0%	89%
RMT-t172-r51-d1	51	47087.4	5.0	40	49156.6	0.3	22%	-4%	94%
RMT-t176-r26-d1	26	48343.4	3.9	21	49129.7	0.2	19%	-2%	95%
RMT-t181-r23-d1	23	22543.4	2.5	20	23009.9	0.5	13%	-2%	79%
RMT-t186-r15-d1	15	21746.1	2.3	12	22306.5	0.2	20%	-3%	90%
RMT-t190-r8-d1	8	18992.5	2.4	7	17979.4	0.3	13%	5%	89%
RMT-t195-r51-d1	51	45783.0	6.1	41	46780.0	0.3	20%	-2%	95%
RMT-t200-r36-d1	36	50536.7	5.1	31	50770.2	0.4	14%	0%	92%
RMT-t204-r19-d1	19	18806.3	3.3	16	18672.0	0.3	16%	1%	91%
RMT-t209-r16-d1	16	27159.7	3.4	14	27841.5	0.4	13%	-3%	89%
RMT-t214-r11-d1	11	10670.9	3.7	11	11009.3	0.2	0%	-3%	94%
RMT-t219-r73-d1	73	105386.9	12.0	56	100768.5	2.5	23%	4%	80%
RMT-t223-r34-d1	34	39526.6	7.3	24	39575.0	0.4	29%	0%	95%
RMT-t228-r23-d1	23	27874.3	8.5	20	27433.4	0.3	13%	2%	97%
RMT-t233-r16-d1	16	19984.9	7.9	16	20699.2	0.2	0%	-4%	97%
RMT-t237-r14-d1	14	26030.4	4.4	12	23883.0	0.5	14%	8%	88%
RMT-t242-r48-d1	48	66593.4	11.8	39	71531.2	0.7	19%	-7%	94%
RMT-t247-r50-d1	48	36899.1	13.9	39	35368.5	0.7	19%	4%	95%
RMT-t251-r28-d1	28	33466.1	7.8	23	33476.3	0.8	18%	0%	90%
RMT-t256-r16-d1	16	18654.6	6.3	15	17810.4	0.4	6%	5%	94%
RMT-t261-r13-d1	13	27173.3	6.7	11	27170.0	0.3	15%	0%	95%
RMT-t266-r58-d1	58	59557.6	17.2	44	59254.8	2.9	24%	1%	83%
RMT-t270-r35-d1	35	31734.1	11.8	28	32015.7	0.9	20%	-1%	92%
RMT-t275-r28-d1	28	18613.9	9.8	23	18605.5	1.2	18%	0%	88%
RMT-t280-r17-d1	17	37055.4	15.5	13	36248.4	0.4	24%	2%	97%
RMT-t284-r15-d1	14	22595.2	8.5	12	20094.9	0.5	14%	11%	94%
RMT-t289-r60-d1	60	96822.9	25.4	40	87424.8	1.0	33%	10%	96%
RMT-t294-r50-d1	50	49156.2	20.8	40	50520.8	0.6	20%	-3%	97%
RMT-t298-r31-d1	31	36224.1	15.7	24	36101.2	0.5	23%	0%	97%
RMT-t303-r21-d1	21	21629.9	13.3	20	21498.5	0.4	5%	1%	97%
RMT-t308-r13-d1	13	29574.2	18.4	10	28314.8	0.4	23%	4%	98%
RMT-t313-r71-d1	71	89299.3	36.0	61	97276.0	1.2	14%	-9%	97%
RMT-t317-r53-d1	53	61336.4	24.8	40	63974.8	7.4	25%	-4%	70%
RMT-t322-r28-d1	28	28188.9	16.2	24	28187.9	0.9	14%	0%	95%
RMT-t327-r20-d1	20	26166.2	14.2	16	25113.9	1.0	20%	4%	93%
RMT-t331-r15-d1	14	30334.5	12.3	12	28583.9	1.3	14%	6%	90%
RMT-t336-r84-d1	84	140377.9	52.6	60	136583.5	1.6	29%	3%	97%
RMT-t344-r43-d1	43	37130.3	28.4	34	37347.4	1.7	21%	-1%	94%
RMT-t351-r40-d1	40	23818.7	30.1	35	25103.1	0.8	13%	-5%	97%
RMT-t359-r29-d1	29	53765.7	24.5	21	47485.3	1.0	28%	12%	96%
RMT-t367-r17-d1	17	24772.2	31.6	15	24280.8	0.6	12%	2%	98%
RMT-t376-r94-d1	94	128376.2	73.4	70	117953.5	19.0	26%	8%	74%
RMT-t384-r52-d1	52	52675.9	45.5	41	54227.0	3.9	21%	-3%	91%
RMT-t393-r38-d1	38	35381.1	36.8	31	34753.8	2.4	18%	2%	94%
RMT-t401-r29-d1	29	58842.8	49.4	25	57204.1	1.5	14%	3%	97%
RMT-t411-r19-d1	18	22918.0	44.2	14	21043.6	0.7	22%	8%	98%
RMT-t420-r130-d1	130	85262.9	135.1	106	92992.9	5.0	18%	-9%	96%
RMT-t429-r61-d1	61	53718.7	68.6	48	54639.2	5.6	21%	-2%	92%
RMT-t439-r37-d1	36	33241.0	45.0	33	33345.8	4.5	8%	0%	90%
RMT-t449-r29-d1	29	50154.3	50.1	26	55893.3	1.5	10%	-11%	97%
RMT-t459-r26-d1	26	25595.5	57.8	20	21312.6	1.0	23%	17%	98%
RMT-t469-r138-d1	138	187664.3	195.1	100	166079.1	23.0	28%	12%	88%
RMT-t480-r70-d1	70	73481.4	110.6	57	73323.1	11.9	19%	0%	89%
RMT-t491-r59-d1	59	56155.8	106.8	52	65360.3	2.3	12%	-16%	98%
RMT-t502-r39-d1	38	54155.5	70.6	33	52074.5	8.3	13%	4%	88%
RMT-t513-r21-d1	21	29579.5	56.8	18	26872.3	1.2	14%	9%	98%
RMT-t524-r153-d1	145	145495.5	257.8	91	128556.2	13.8	37%	12%	95%
RMT-t536-r96-d1	96	98642.1	216.0	81	100812.1	4.8	16%	-2%	98%
RMT-t548-r50-d1	49	69755.2	118.6	41	67244.5	18.1	16%	4%	85%
RMT-t561-r42-d1	42	46341.8	123.6	32	43251.5	2.1	24%	7%	98%
RMT-t573-r30-d1	30	50195.3	155.0	24	44638.9	4.5	20%	11%	97%
RMT-t586-r159-d1	159	149940.3	433.7	108	137733.1	50.0	32%	8%	88%
RMT-t599-r92-d1	92	84144.8	279.9	69	87576.7	26.1	25%	-4%	91%
RMT-t613-r62-d1	62	55743.9	222.4	56	60907.6	2.8	10%	-9%	99%
RMT-t627-r43-d1	43	52126.9	157.1	32	51605.5	12.1	26%	1%	92%
RMT-t641-r35-d1	35	56323.9	147.5	28	52566.5	8.6	20%	7%	94%
RMT-t655-r131-d1	131	91921.6	493.9	95	79489.4	113.4	27%	14%	77%
RMT-t670-r130-d1	127	137028.3	587.1	94	146015.6	13.2	26%	-7%	98%
RMT-t685-r75-d1	75	60740.0	465.6	64	67118.5	4.2	15%	-11%	99%
RMT-t701-r44-d1	44	84854.1	245.5	31	73369.2	7.6	30%	14%	97%

*Continues on the next page*



Table 7 – Continued from the previous page

Instance Name	a-nCAR			DoNe-CPTA			Performance DoNe-CPTA vs a-nCAR		
	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time
RMT-t716-r35-d1	35	41968.0	210.1	27	41008.3	4.8	23%	2%	98%
RMT-t733-r159-d1	159	109315.5	921.5	129	122351.6	23.8	19%	-12%	97%
RMT-t749-r98-d1	98	75866.6	575.3	74	78394.1	7.5	24%	-3%	99%
RMT-t766-r71-d1	71	114724.9	766.6	48	105215.9	10.6	32%	8%	99%
RMT-t783-r48-d1	48	66102.3	479.3	41	72224.6	6.2	15%	-9%	99%
RMT-t801-r40-d1	39	62794.4	299.2	31	56182.0	37.7	21%	11%	87%
RMT-t819-r171-d1	171	126472.5	1247.9	140	123660.5	179.4	18%	2%	86%
RMT-t837-r142-d1	142	149731.5	1143.2	111	146780.4	151.4	22%	2%	87%
RMT-t856-r95-d1	95	72800.3	781.6	79	68516.5	103.0	17%	6%	87%
RMT-t876-r59-d1	59	81602.5	593.2	51	84518.1	11.5	14%	-4%	98%
RMT-t895-r37-d1	37	58974.9	409.3	26	49448.3	15.4	30%	16%	96%
RMT-t916-r207-d1	207	267216.8	2129.5	154	235248.9	306.2	26%	12%	86%
RMT-t936-r151-d1	151	129228.7	1919.7	118	138542.0	25.8	22%	-7%	99%
RMT-t957-r87-d1	87	70400.4	1025.5	71	66075.7	140.8	18%	6%	86%
RMT-t979-r58-d1	58	102060.0	1030.7	51	107255.5	18.8	12%	-5%	98%
RMT-t1001-r43-d1	43	76648.9	715.9	30	65523.2	15.0	30%	15%	98%
AVERAGE:							18%	1%	92%

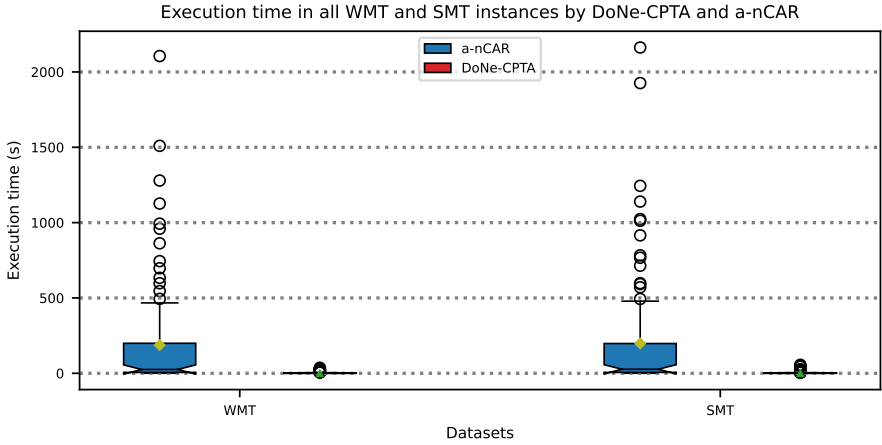
Table 8: All test results for XMT instances (CVRP) by DoNe-CPTA and a-nCAR

Instance Name	a-nCAR			DoNe-CPTA			Performance DoNe-CPTA vs a-nCAR		
	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time
XMT-t101-r25-d1	25	42276.0	0.5	25	47422.0	0.1	0%	-12%	80%
XMT-t106-r14-d1	14	36992.0	0.4	14	40600.0	0.1	0%	-10%	66%
XMT-t110-r13-d1	13	23324.0	0.5	13	25216.0	0.1	0%	-8%	80%
XMT-t115-r10-d1	10	21074.0	0.8	10	21888.0	0.1	0%	-4%	90%
XMT-t120-r6-d1	6	22228.0	0.5	6	22766.0	0.1	0%	-2%	81%
XMT-t125-r30-d1	30	79640.0	1.3	30	86386.0	0.2	0%	-8%	87%
XMT-t129-r18-d1	18	42200.0	0.9	18	49066.0	0.1	0%	-16%	85%
XMT-t134-r13-d1	13	16346.0	1.2	13	20924.0	0.1	0%	-28%	89%
XMT-t139-r10-d1	10	22294.0	0.8	10	24552.0	0.1	0%	-10%	87%
XMT-t143-r7-d1	7	26904.0	1.1	7	30194.0	0.1	0%	-12%	89%
XMT-t148-r46-d1	46	61926.0	2.6	46	70482.0	0.3	0%	-14%	90%
XMT-t153-r22-d1	22	35478.0	2.1	22	33912.0	0.2	0%	4%	91%
XMT-t157-r13-d1	13	23180.0	1.2	13	23834.0	0.3	0%	-3%	75%
XMT-t162-r11-d1	11	23388.0	1.3	11	23058.0	0.1	0%	1%	89%
XMT-t167-r10-d1	10	33428.0	1.4	10	31462.0	0.2	0%	6%	87%
XMT-t172-r51-d1	51	70760.0	4.5	51	78980.0	0.4	0%	-12%	92%
XMT-t176-r26-d1	26	75486.0	3.2	26	80342.0	0.3	0%	-6%	92%
XMT-t181-r23-d1	23	35352.0	2.4	23	43980.0	0.7	0%	-24%	72%
XMT-t186-r15-d1	15	37256.0	2.2	15	39132.0	0.3	0%	-5%	87%
XMT-t190-r8-d1	8	26082.0	2.2	8	26134.0	0.3	0%	0%	88%
XMT-t195-r51-d1	51	67658.0	6.0	51	72502.0	0.4	0%	-7%	94%
XMT-t200-r36-d1	36	72978.0	5.2	36	80310.0	0.5	0%	-10%	90%
XMT-t204-r19-d1	19	29114.0	3.2	19	32818.0	0.3	0%	-13%	91%
XMT-t209-r16-d1	16	46968.0	3.3	16	48940.0	0.4	0%	-4%	87%
XMT-t214-r11-d1	11	18030.0	3.5	11	17280.0	0.3	0%	4%	93%
XMT-t219-r73-d1	73	156792.0	10.4	73	185068.0	3.7	0%	-18%	65%
XMT-t223-r34-d1	34	58322.0	7.0	34	62964.0	0.4	0%	-8%	94%
XMT-t228-r23-d1	23	39722.0	6.9	23	44168.0	0.3	0%	-11%	95%
XMT-t233-r16-d1	16	32910.0	7.4	16	35590.0	0.2	0%	-8%	97%
XMT-t237-r14-d1	14	41476.0	4.0	14	41182.0	0.7	0%	1%	83%
XMT-t242-r48-d1	48	115122.0	11.1	48	133782.0	0.8	0%	-16%	93%
XMT-t247-r50-d1	50	58948.0	10.8	50	57998.0	1.1	0%	2%	90%
XMT-t251-r28-d1	28	57730.0	7.6	28	59640.0	1.0	0%	-3%	87%
XMT-t256-r16-d1	16	32226.0	5.8	16	28864.0	0.4	0%	10%	93%
XMT-t261-r13-d1	13	42634.0	6.6	13	46084.0	0.3	0%	-8%	95%
XMT-t266-r58-d1	58	107892.0	16.6	58	115976.0	2.4	0%	-7%	85%
XMT-t270-r35-d1	35	52114.0	11.5	35	56110.0	1.2	0%	-8%	90%
XMT-t275-r28-d1	28	31940.0	9.1	28	37732.0	1.5	0%	-18%	84%
XMT-t280-r17-d1	17	52336.0	15.2	17	58196.0	0.4	0%	-11%	97%
XMT-t284-r15-d1	15	32794.0	8.0	15	33198.0	0.5	0%	-1%	93%
XMT-t289-r60-d1	60	144886.0	23.1	60	162094.0	1.2	0%	-12%	95%
XMT-t294-r50-d1	50	70148.0	18.8	50	80984.0	0.7	0%	-15%	96%
XMT-t298-r31-d1	31	52918.0	15.0	31	59624.0	0.6	0%	-13%	96%
XMT-t303-r21-d1	21	35742.0	13.0	21	37464.0	0.5	0%	-5%	96%
XMT-t308-r13-d1	13	44306.0	17.3	13	46104.0	0.4	0%	-4%	97%
XMT-t313-r71-d1	71	134030.0	33.0	71	150512.0	1.7	0%	-12%	95%
XMT-t317-r53-d1	53	107044.0	23.2	53	164592.0	8.8	0%	-54%	62%
XMT-t322-r28-d1	28	44830.0	16.6	28	47374.0	1.2	0%	-6%	93%
XMT-t327-r20-d1	20	44158.0	13.5	20	46108.0	1.1	0%	-4%	92%
XMT-t331-r15-d1	15	51478.0	11.3	15	47730.0	1.7	0%	7%	85%
XMT-t336-r84-d1	84	207832.0	47.8	84	235332.0	2.2	0%	-13%	95%
XMT-t344-r43-d1	43	61694.0	27.7	43	66592.0	2.3	0%	-8%	92%
XMT-t351-r40-d1	40	40510.0	28.7	40	43172.0	0.9	0%	-7%	97%
XMT-t359-r29-d1	29	75062.0	23.6	29	81110.0	1.1	0%	-8%	95%

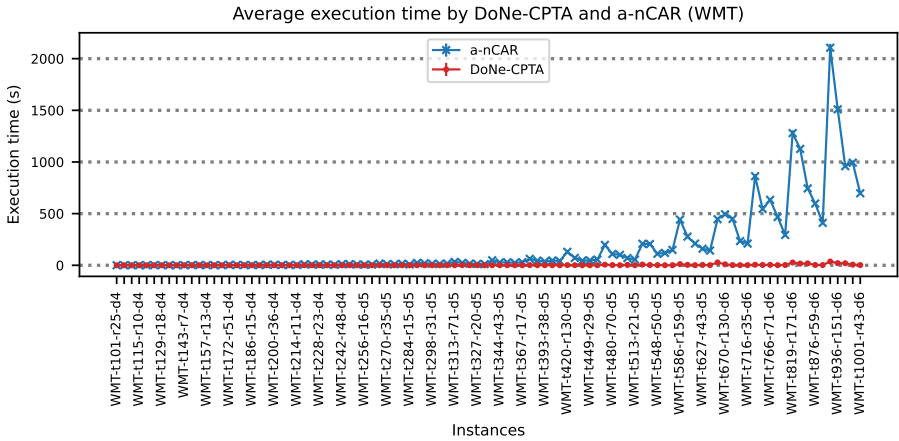
Continues on the next page

10 *Supplementary Material*Table 8 – *Continued from the previous page*

Instance Name	a-nCAR			DoNe-CPTA			Performance DoNe-CPTA vs a-nCAR		
	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time (s)	# Robot	Cost	Exec. Time
XMT-t367-r17-d1	17	35616.0	29.9	17	37262.0	0.6	0%	-5%	98%
XMT-t376-r94-d1	94	195072.0	62.9	94	238458.0	18.8	0%	-22%	70%
XMT-t384-r52-d1	52	93558.0	45.7	52	102214.0	4.1	0%	-9%	91%
XMT-t393-r38-d1	38	58228.0	36.6	38	59888.0	2.8	0%	-3%	92%
XMT-t401-r29-d1	29	98256.0	46.1	29	101804.0	1.6	0%	-4%	96%
XMT-t411-r19-d1	19	34056.0	41.2	19	33608.0	0.7	0%	1%	98%
XMT-t420-r130-d1	130	147482.0	130.3	130	168696.0	5.0	0%	-14%	96%
XMT-t429-r61-d1	61	94964.0	70.9	61	100148.0	6.2	0%	-5%	91%
XMT-t439-r37-d1	37	52444.0	44.9	37	55854.0	5.6	0%	-7%	87%
XMT-t449-r29-d1	29	85420.0	48.3	29	97980.0	1.5	0%	-15%	97%
XMT-t459-r26-d1	26	40168.0	55.8	26	38128.0	1.1	0%	5%	98%
XMT-t469-r138-d1	138	312568.0	197.0	138	344908.0	22.9	0%	-10%	88%
XMT-t480-r70-d1	70	126646.0	108.6	70	134594.0	11.5	0%	-6%	89%
XMT-t491-r59-d1	59	95912.0	100.9	59	117394.0	2.6	0%	-22%	97%
XMT-t502-r39-d1	39	89688.0	70.4	39	106942.0	16.5	0%	-19%	77%
XMT-t513-r21-d1	21	43266.0	55.6	21	42308.0	1.3	0%	2%	98%
XMT-t524-r153-d1	153	228128.0	206.8	153	227738.0	26.9	0%	0%	87%
XMT-t536-r96-d1	96	149420.0	202.5	96	159002.0	6.6	0%	-6%	97%
XMT-t548-r50-d1	50	122182.0	111.6	50	165644.0	23.5	0%	-36%	79%
XMT-t561-r42-d1	42	71284.0	118.8	42	72672.0	2.5	0%	-2%	98%
XMT-t573-r30-d1	30	72170.0	146.3	30	73424.0	5.0	0%	-2%	97%
XMT-t586-r159-d1	159	257450.0	428.8	159	287602.0	53.6	0%	-12%	87%
XMT-t599-r92-d1	92	151936.0	273.0	92	163578.0	26.5	0%	-8%	90%
XMT-t613-r62-d1	62	96100.0	212.2	62	103696.0	3.3	0%	-8%	98%
XMT-t627-r43-d1	43	90504.0	158.7	43	93370.0	15.5	0%	-3%	90%
XMT-t641-r35-d1	35	95112.0	142.3	35	93712.0	14.5	0%	1%	90%
XMT-t655-r131-d1	131	145276.0	445.2	131	169146.0	135.0	0%	-16%	70%
XMT-t670-r130-d1	130	221120.0	495.1	130	220298.0	24.6	0%	0%	95%
XMT-t685-r75-d1	75	108918.0	440.6	75	115248.0	4.9	0%	-6%	99%
XMT-t701-r44-d1	44	120248.0	232.7	44	127508.0	8.7	0%	-6%	96%
XMT-t716-r35-d1	35	68402.0	208.5	35	78898.0	5.1	0%	-15%	98%
XMT-t733-r159-d1	159	191404.0	849.5	159	225060.0	17.7	0%	-18%	98%
XMT-t749-r98-d1	98	112188.0	539.5	98	131096.0	9.1	0%	-17%	98%
XMT-t766-r71-d1	71	169206.0	615.8	71	187602.0	7.5	0%	-11%	99%
XMT-t783-r48-d1	48	118380.0	460.9	48	126504.0	7.5	0%	-7%	98%
XMT-t801-r40-d1	40	107850.0	291.0	40	152880.0	56.2	0%	-42%	81%
XMT-t819-r171-d1	171	222340.0	1268.7	171	240552.0	109.2	0%	-8%	91%
XMT-t837-r142-d1	142	269386.0	1105.7	142	285564.0	156.1	0%	-6%	86%
XMT-t856-r95-d1	95	121156.0	734.7	95	146078.0	132.1	0%	-21%	82%
XMT-t876-r59-d1	59	139160.0	585.9	59	146648.0	12.7	0%	-5%	98%
XMT-t895-r37-d1	37	84696.0	406.4	37	84720.0	30.8	0%	0%	92%
XMT-t916-r207-d1	207	449230.0	2066.7	207	491004.0	266.1	0%	-9%	87%
XMT-t936-r151-d1	151	203234.0	1508.3	151	210178.0	55.0	0%	-3%	96%
XMT-t957-r87-d1	87	121740.0	951.5	87	151904.0	189.4	0%	-25%	80%
XMT-t979-r58-d1	58	176458.0	978.5	58	188926.0	19.6	0%	-7%	98%
XMT-t1001-r43-d1	43	110920.0	694.9	43	110146.0	18.4	0%	1%	97%
AVERAGE:							0%	-9%	90%



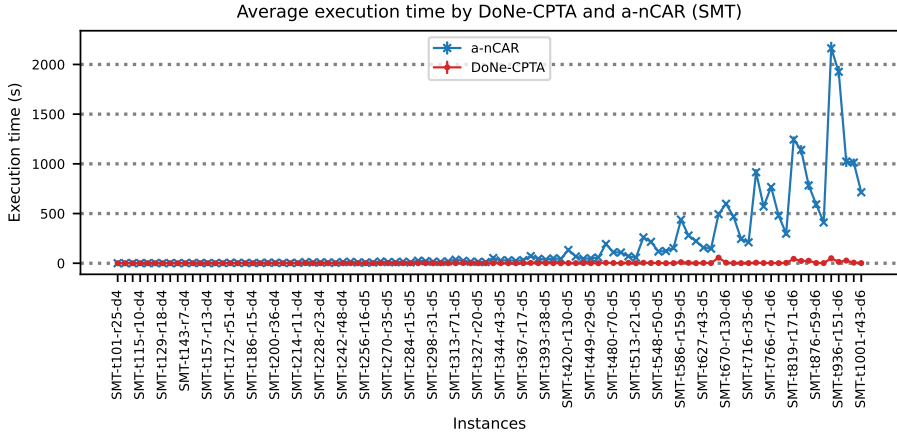
**Figure 4** Overview of the execution times by DoNe-CPTA and a-nCAR both running SMT and WMT instances.



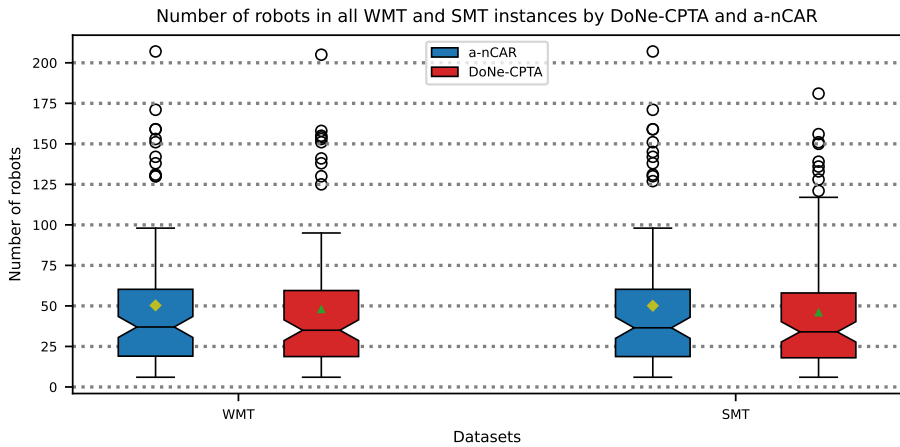
**Figure 5** Execution times by DoNe-CPTA and a-nCAR both running WMT instances.

**Table 6** Mann-Whitney U test results for number of robots by DoNe-CPTA and a-nCAR on SMT and WMT. Skewed right data by Shapiro Wilk.

Dataset	Significance Level	p-value	Result	Common-Language Effect Size
WMT	0.05	0.6653	Do not reject $H_0$	48%
SMT	0.05	0.5015	Do not reject $H_0$	47%



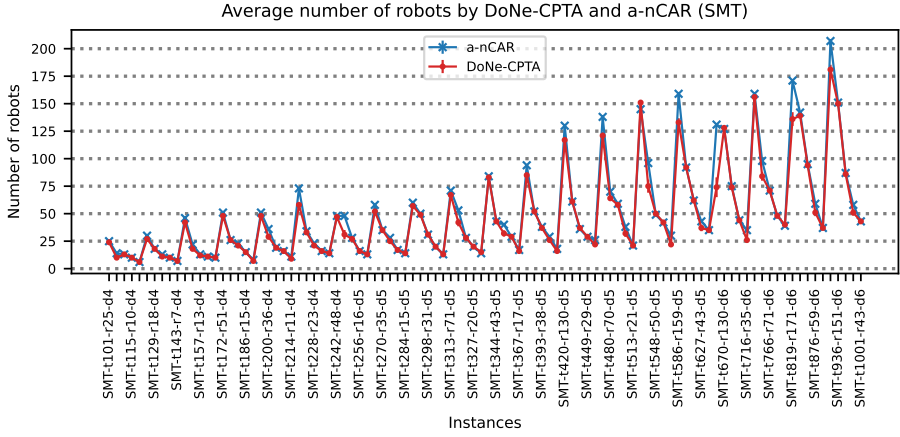
**Figure 6** Execution times by DoNe-CPTA and a-nCAR both running SMT instances.



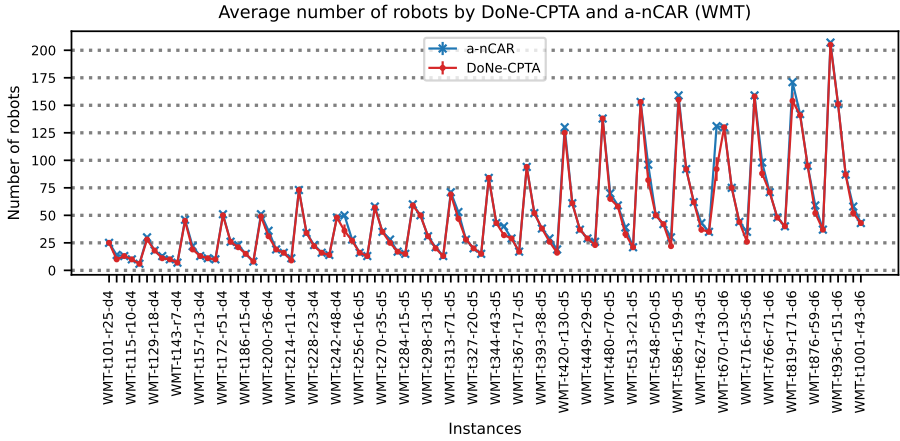
**Figure 7** Overview of the number of robots by DoNe-CPTA and a-nCAR both running SMT and WMT instances.

**Table 9** Mann-Whitney U test results for route costs by DoNe-CPTA and a-nCAR on RMT and XMT. Skewed right data by Shapiro Wilk.

Dataset	Significance Level	p-value	Result	Common-Language Effect Size
XMT	0.05	0.4278	Do not reject $H_0$	53%
RMT	0.05	0.8786	Do not reject $H_0$	49%



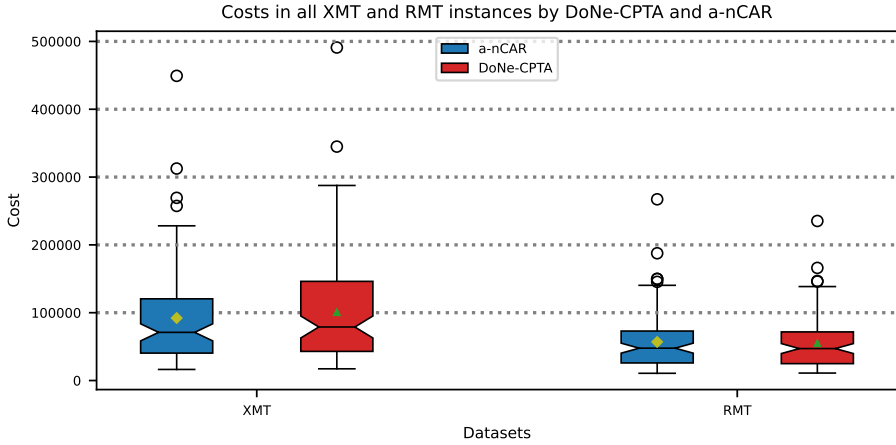
**Figure 8** Number of robots by DoNe-CPTA and a-nCAR both running SMT instances.



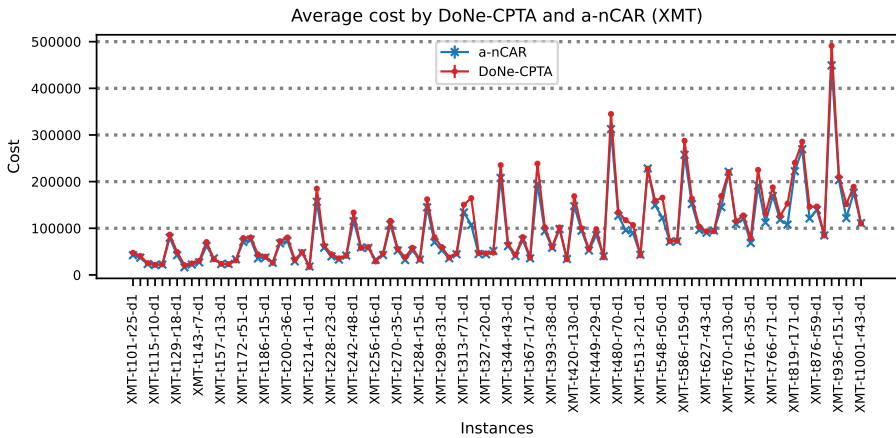
**Figure 9** Number of robots by DoNe-CPTA and a-nCAR both running WMT instances.

**Table 10** Mann-Whitney U test results for execution time by DoNe-CPTA and a-nCAR on RMT and XMT. Skewed right data by Shapiro Wilk.

Dataset	Significance Level	p-value	Result	Common-Language Effect Size
XMT	0.05	$2.007 \times 10^{-13}$	Reject $H_0$	20%
RMT	0.05	$3.886 \times 10^{-15}$	Reject $H_0$	18%



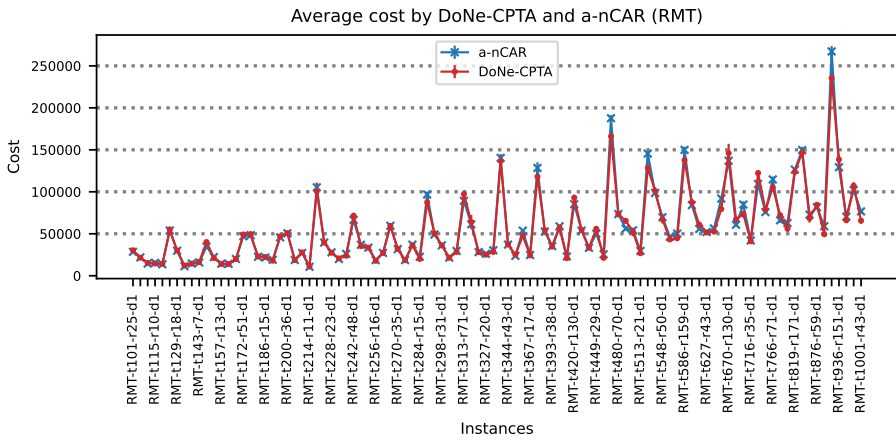
**Figure 10** Overview of the route costs by DoNe-CPTA and a-nCAR both running RMT and XMT instances.



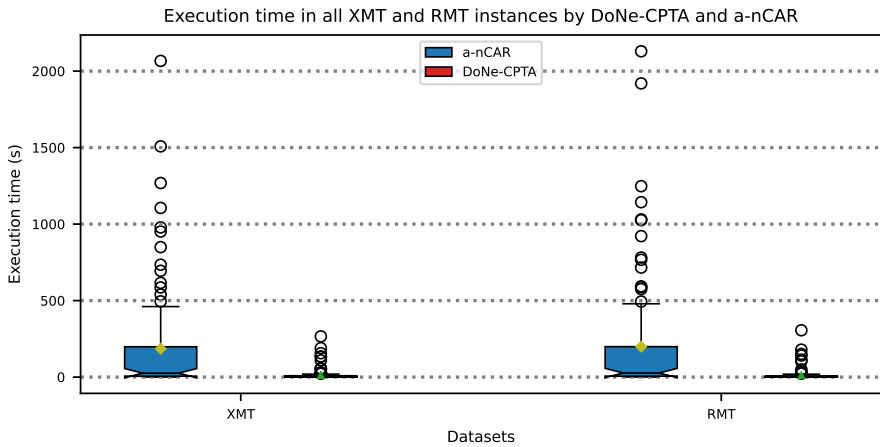
**Figure 11** Route costs by DoNe-CPTA and a-nCAR both running XMT instances.

**Table 11** Mann-Whitney U test results for number of robots by DoNe-CPTA and a-nCAR on RMT and XMT. Skewed right data by Shapiro Wilk.

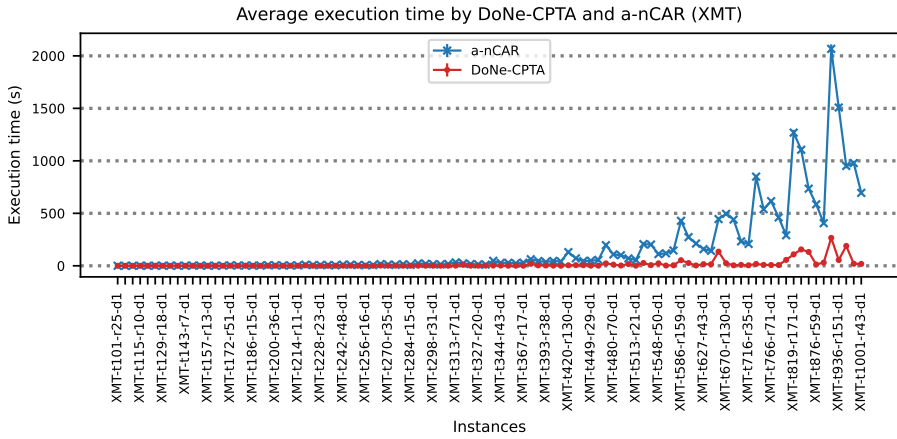
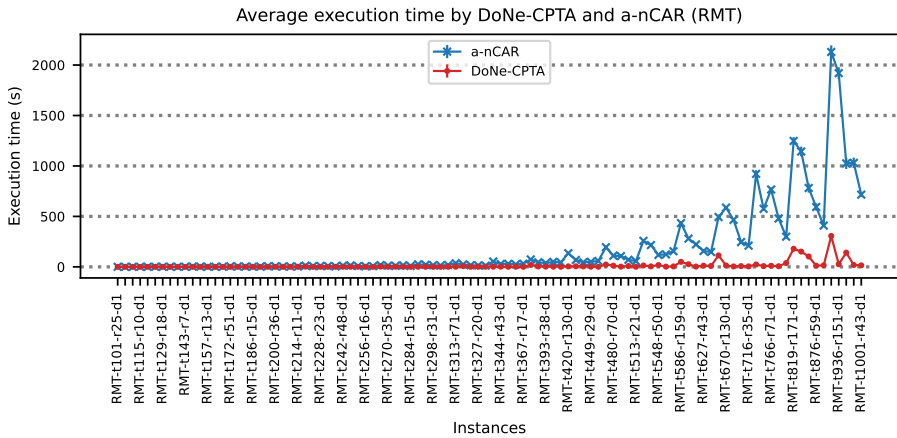
Dataset	Significance Level	p-value	Result	Common-Language Effect Size
XMT	0.05	0.999	Do not reject $H_0$	50%
RMT	0.05	0.07911	Do not reject $H_0$	43%



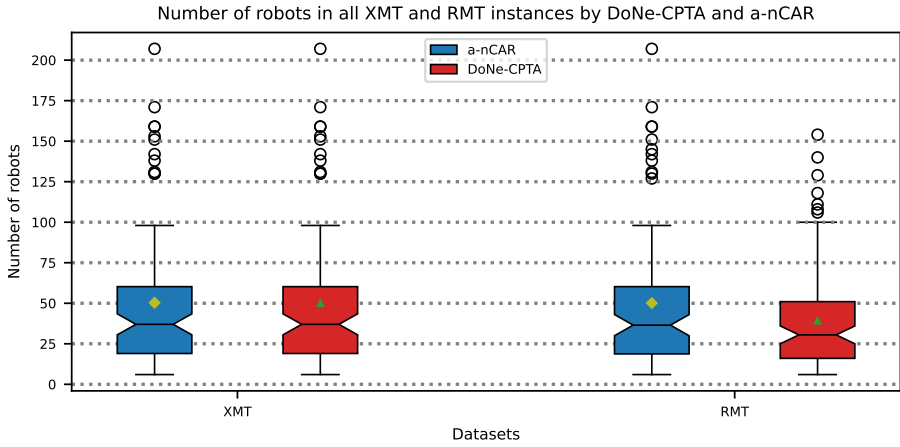
**Figure 12** Route costs by DoNe-CPTA and a-nCAR both running RMT instances.



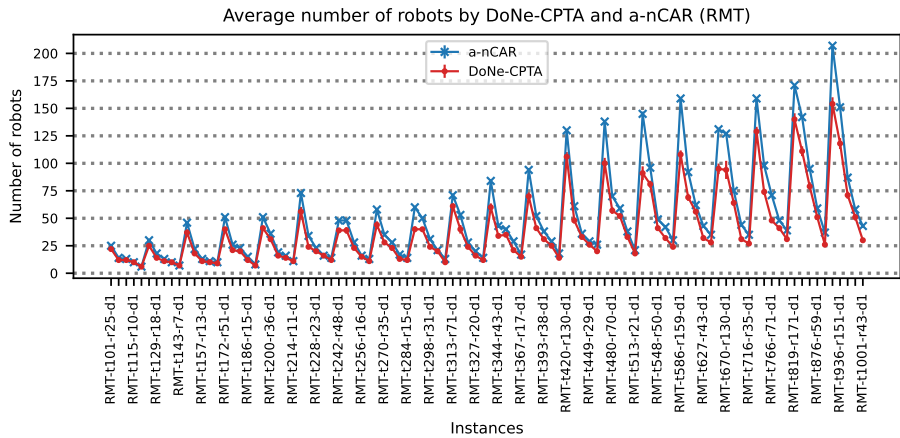
**Figure 13** Overview of the execution times by DoNe-CPTA and a-nCAR both running RMT and XMT instances.

**Figure 14** Execution times by DoNe-CPTA and a-nCAR both running XMT instances.**Figure 15** Execution times by DoNe-CPTA and a-nCAR both running RMT instances.

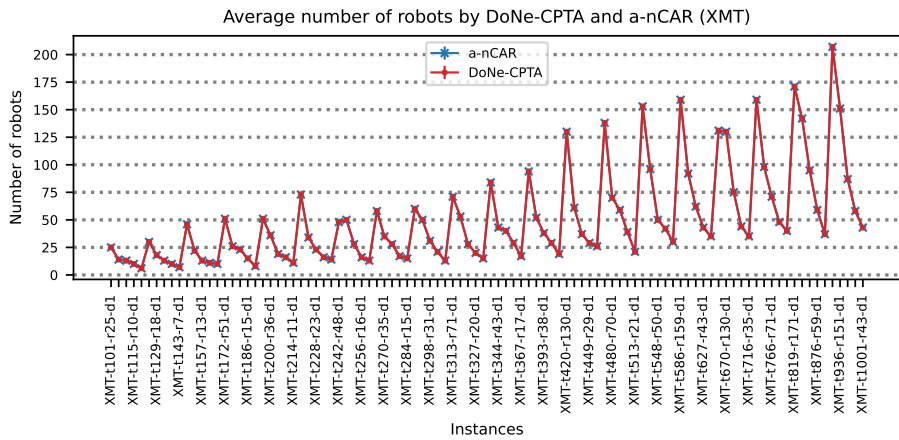




**Figure 16** Overview of the number of robots by DoNe-CPTA and a-nCAR both running RMT and XMT instances.



**Figure 17** Number of robots by DoNe-CPTA and a-nCAR both running RMT instances.



**Figure 18** Number of robots by DoNe-CPTA and a-nCAR both running XMT instances.