Clique Analysis and Bypassing in Continuous-Time Conflict-Based Search

Supplementary results to the publication at SoCS 2024

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1 Overview

This supplementary material includes full MAPF benchmark results that go with the paper. The first section contains benchmark results and the second section contains significance testing to show the best variant versus previous state-of-the-art.

2 Summary of Benchmark Tests

The following tables show the results of all MAPF benchmarks and tests. The statistics are the total number of problem instances solved in each category in under 30 seconds for each test, with the 95th percentile marked with ±. The best result in each setting is underlined, and all results that are statistically inside the 95th percentile of the best result are in bold.

Table 1: Total problems solved in under 30 seconds on 4-neighbor grid MAPF benchmarks

Map	CCBS With Bypass				CCBS Without Bypass			
	CCBS	DS	BC	KDB	CCBS	DS[1]	BC	KDB
Berlin_1_256	1,198±52	**1,334±56**	1,198±52	**1,334±56**	1,182±53	1,200±53	1,188±53	1,200±53
Boston_0_256	**1,120±34**	**1,140±40**	**1,120±34**	**1,152±40**	**1,122±34**	**1,112±37**	**1,122±34**	**1,112±37**
Paris_1_256	**1,504±58**	**1,524±56**	**1,504±58**	**1,524±56**	1,356±55	1,432±59	1,356±55	1,434±58
city	3,822±72	**3,998±153**	3,822±145	**4,010±153**	3,660±142	3,744±150	3,666±142	3,746±150
den520d	**858±32**	**860±33**	**858±32**	**868±33**	**844±32**	**844±32**	**844±32**	**844±32**
brc202d	514±12	**604±20**	522±13	**606±20**	510±15	580±18	510±15	586±17
den312d	504±16	510±14	504±16	**552±15**	464±13	474±13	464±13	474±13
lak303d	470±15	**538±14**	472±15	**552±14**	410±12	474±14	412±12	476±14
orz900d	524±15	566±15	528±15	564±16	544±20	**626±21**	542±20	**622±21**
ost003d	**572±22**	**582±21**	**572±22**	**582±21**	554±21	**562±21**	554±21	**564±21**
DAO	3,442±57	**3,660±119**	3,456±116	**3,724±121**	3,326±116	3,560±122	3,326±116	3,566±121
empty-16-16	516±20	520±20	516±20	**546±22**	518±20	520±20	518±20	520±20
empty-32-32	**930±37**	**920±33**	**930±37**	**918±34**	**910±35**	886±33	**910±35**	886±33
empty-48-48	1,086±39	1,110±36	1,086±39	**1,144±33**	1,060±38	1,058±35	1,056±38	1,058±35
empty-8-8	292±8	316±8	292±8	**338±8**	296±9	312±8	296±9	314±8
empty	2,824±52	**2,866±98**	2,824±105	**2,946±98**	2,784±104	2,776±97	2,780±104	2,778±98
lt_gallowstemplar_n	610±19	**654±20**	610±19	**658±19**	562±16	632±19	564±16	634±19
ht_chantry	544±14	**588±17**	540±14	**592±16**	522±11	570±16	518±12	566±16
ht_mansion_n	700±19	726±18	716±19	**746±19**	662±20	680±19	664±20	680±19
w_woundedcoast	656±19	**698±20**	668±17	**706±18**	632±20	664±20	636±19	670±20
DAO2	2,510±36	**2,666±76**	2,534±71	**2,702±73**	2,378±69	2,546±75	2,382±68	2,550±75
maze-32-32-2	274±5	278±5	**282±5**	278±6	272±6	**280±5**	**280±6**	**286±6**
maze-32-32-4	248±7	**256±7**	248±7	**254±7**	246±7	**252±7**	246±7	248±7
maze-128-128-2	210±6	**254±6**	210±6	**256±6**	210±6	248±6	210±6	**252±7**
maze-128-128-10	304±9	**364±11**	304±9	**360±11**	296±9	340±10	296±9	340±11
maze	1,226±19	**1,336±41**	1,234±39	1,148±31	1,214±39	**1,304±41**	1,222±39	**1,310±41**
random-64-64-10	1,226±43	1,222±40	1,226±43	**1,266±39**	**1,232±41**	1,210±39	**1,232±41**	1,210±39
random-64-64-20	856±29	860±30	864±30	**920±32**	842±28	862±30	842±28	852±30
random-32-32-10	**664±25**	**674±26**	**664±25**	**674±26**	**680±28**	614±25	**680±28**	614±25
random-32-32-20	**450±19**	**438±17**	**450±19**	**448±18**	**450±19**	424±16	**450±19**	424±16
random	**3,196±59**	**3,194±116**	**3,204±119**	**3,308±117**	**3,204±118**	3,110±113	**3,204±118**	3,100±112
room-64-64-16	**428±16**	**432±16**	**428±16**	**428±15**	**418±15**	**424±15**	**420±15**	**424±16**
room-64-64-8	292±10	288±10	292±10	**314±10**	290±9	290±10	290±9	290±10
room-32-32-4	282±11	**298±11**	286±11	**306±12**	282±11	286±11	286±11	286±11
room	1,002±18	**1,018±38**	1,006±37	**1,048±38**	990 ±36	1,000±37	996 ±37	1,000±37
w-10-20-10-2-2	1,134±45	**1,372±65**	1,134±45	**1,390±70**	1,138±45	1,124±45	1,138±45	1,124±45
w-10-20-10-2-1	1,018±39	**1,078±43**	1,018±39	**1,066±40**	**1,042±41**	1,022±40	**1,042±41**	1,022±40
w-20-40-10-2-2	**1,972±61**	**1,998±64**	**1,972±61**	**1,998±64**	1,906±60	1,890±61	1,906±60	1,890±61
w-20-40-10-2-1	1,838±47	1,870±45	1,838±47	**2,038±53**	1,772±48	1,740±38	1,772±48	1,740±38
warehouse	5,962±96	**6,318±218**	5,962±193	**6,492±228**	5,858±196	5,776±185	5,858±196	5,776±185
Total	25,572±897	**26,816±935**	25,632±899	**26,860±934**	25,014±893	25,564±895	25,036±894	25,574±894

[1] Previous state-of-the-art.

Table 2: Total problems solved in under 30 seconds on 8-neighbor grid MAPF benchmarks

Map	CCBS With Bypass				CCBS Without Bypass			
	CCBS	DS	BC	KDB	CCBS	DS[1]	BC	KDB
Berlin_1_256	1,654±46	1,702±44	**1,740±49**	1,674±44	1,576±47	1,666±45	1,666±46	**1,718±47**
Boston_0_256	1,474±46	**1,604±52**	1,532±50	**1,626±52**	1,458±46	1,554±50	1,528±50	**1,612±52**
Paris_1_256	1,668±55	1,710±55	1,672±55	**1,784±54**	1,572±53	1,600±51	1,608±55	1,652±55
city	4,796±74	**5,016±153**	4,944±156	**5,084±150**	4,606±146	4,820±147	4,802±151	4,982±155
den520d	954±31	982±32	**992±32**	**1,022±34**	934±31	986±30	986±32	**1,004±30**
brc202d	762±15	854±17	820±16	**876±15**	752±15	836±17	800±16	**876±19**
den312d	568±14	**640±20**	572±15	600±17	554±14	600±18	556±14	606±19
lak303d	536±11	572±12	548±11	**596±12**	522±12	562±13	548±11	572±12
orz900d	576±14	634±14	606±15	**656±15**	578±14	622±14	594±14	628±15
ost003d	646±22	**712±22**	648±22	**724±24**	640±22	692±21	646±22	696±21
DAO	4,042±55	**4,394±119**	4,186±114	**4,474±120**	3,980±111	4,298±116	4,130±112	**4,382±119**
empty-8-8	400±6	408±6	412±6	**422±6**	402±6	400±6	**420±6**	408±6
empty-16-16	536±13	594±14	526±13	**658±16**	520±13	616±17	526±13	618±17
empty-32-32	976±29	1,128±30	1,008±27	**1,146±26**	922±28	1,000±23	958±26	1,032±26
empty-48-48	1,258±39	**1,430±47**	1,302±45	**1,402±43**	1,288±43	1,288±41	1,366±51	1,338±48
empty	3,170±44	**3,560±99**	3,248±93	**3,628±92**	3,132±91	3,304±89	3,270±98	3,396±98
lt_gallowstemplar_n	738±18	**870±19**	768±20	**864±21**	748±18	818±18	768±19	820±20
ht_chantry	742±15	774±15	762±16	**810±18**	732±15	768±14	748±15	786±15
ht_mansion_n	800±21	872±22	816±22	**908±23**	762±19	796±21	792±20	818±20
w_woundedcoast	716±14	**802±14**	740±14	**798±13**	704±15	792±14	736±14	**818±14**
DAO2	2,996±35	**3,318±71**	3,086±74	**3,380±75**	2,946±69	3,174±69	3,044±70	3,242±70
maze-32-32-2	282±4	298±4	290±4	**308±5**	280±5	**308±5**	286±5	**304±5**
maze-32-32-4	258±8	260±8	260±8	**274±9**	258±8	260±8	260±8	260±8
maze-128-128-2	244±6	**260±7**	240±6	**264±7**	244±6	**262±7**	242±6	**262±7**
maze-128-128-10	458±10	474±11	458±10	**490±11**	454±10	474±11	454±10	472±12
maze	1,242±15	1,292±32	1,248±30	**1,336±33**	1,236±31	**1,304±33**	1,242±31	1,298±33
random-64-64-10	1,242±33	1,354±24	1,266±35	**1,448±27**	1,162±30	1,282±25	1,196±34	1,304±28
random-64-64-20	**870±19**	852±21	**884±20**	**884±24**	862±19	860±21	**870±19**	858±21
random-32-32-10	878±24	894±25	872±23	**934±24**	840±22	842±22	846±22	846±22
random-32-32-20	502±17	**528±18**	**516±19**	494±17	504±17	502±18	**514±18**	506±18
random	3,492±47	3,628±90	3,538±98	**3,760±94**	3,368±90	3,486±87	3,426±95	3,514±90
room-64-64-16	466±13	480±14	466±14	**500±16**	466±13	476±14	466±14	478±14
room-64-64-8	332±8	**340±8**	326±8	**336±9**	330±8	**342±8**	324±8	330±8
room-32-32-4	318±9	**328±9**	316±8	**332±8**	306±9	**324±9**	310±9	316±9
room	1,116±15	**1,148±32**	1,108±31	**1,168±33**	1,102±31	**1,142±32**	1,100±31	1,124±32
w-10-20-10-2-2	1,666±57	1,670±48	1,694±56	**1,824±42**	1,532±53	1,558±51	1,538±52	1,568±51
w-10-20-10-2-1	978±33	**1,076±35**	976±33	**1,070±34**	1,012±33	1,036±35	1,010±33	1,030±35
w-20-40-10-2-2	2,572±81	2,484±75	2,602±83	**2,698±75**	2,524±79	2,470±75	2,518±77	2,466±75
w-20-40-10-2-1	1,692±62	**1,760±65**	1,692±62	1,688±59	1,502±53	1,624±58	1,516±55	1,658±60
warehouse	6,908±117	6,990±224	6,964±236	**7,280±212**	6,570±219	6,688±220	6,582±219	6,722±222
Total	27,762±811	29,346±823	28,322±835	**30,110±813**	26,940±792	28,216±796	27,596±810	28,660±824

[1] Previous state-of-the-art.

Table 3: Total problems solved in under 30 seconds on 16-neighbor grid MAPF benchmarks

Map	CCBS With Bypass				CCBS Without Bypass			
	CCBS	DS	BC	KDB	CCBS	DS[1]	BC	KDB
Berlin_1_256	1,220±22	1,400±24	1,230±23	**1,484±28**	1,150±22	1,306±23	1,150±22	1,358±25
Boston_0_256	1,176±32	**1,346±30**	1,190±32	**1,332±37**	1,124±31	**1,332±31**	1,130±31	**1,338±32**
Paris_1_256	1,196±28	1,298±35	1,204±28	**1,332±32**	1,080±29	1,268±31	1,088±29	1,262±31
city	3,592±41	4,044±90	3,624±83	**4,148±99**	3,354±83	3,906±86	3,368±83	3,958±89
den520d	784±21	966±23	806±21	**1,020±28**	762±20	946±24	786±21	946±24
brc202d	596±14	646±12	604±14	**682±11**	594±14	662±13	602±14	668±12
den312d	506±12	594±12	516±13	**624±12**	506±12	586±12	514±12	588±12
lak303d	380±9	442±10	384±9	**478±12**	382±9	436±9	386±9	440±9
orz900d	344±10	400±10	354±10	**426±9**	328±9	400±10	334±9	404±10
ost003d	512±11	**568±13**	514±11	**570±11**	506±11	548±13	506±11	556±13
DAO	3,122±40	3,616±82	3,178±81	**3,800±86**	3,078±78	3,578±83	3,128±79	3,602±83
empty-8-8	384±5	390±5	388±5	**404±5**	384±5	392±5	382±5	392±5
empty-16-16	486±9	582±9	524±10	**602±9**	478±10	562±9	504±9	552±10
empty-32-32	826±22	996±21	870±22	**1,008±21**	792±23	980±20	794±23	**1,012±21**
empty-48-48	1,212±30	**1,358±31**	1,212±30	**1,352±32**	1,128±30	1,318±25	1,128±30	1,322±26
empty	2,908±34	**3,326±67**	2,994±68	**3,366±68**	2,782±69	3,252±61	2,808±68	3,278±63
lt_gallowstemplar_n	656±17	762±18	686±17	**794±16**	648±19	726±19	662±19	734±19
ht_chantry	582±12	**662±14**	596±12	**676±14**	582±12	**662±14**	592±12	656±14
ht_mansion_n	556±13	710±11	562±13	**738±12**	548±12	698±10	564±12	710±11
w_woundedcoast	450±9	528±10	462±10	**568±9**	436±9	512±9	454±10	524±9
DAO2	2,244±26	2,662±54	2,306±54	**2,776±53**	2,214±54	2,598±54	2,272±54	2,624±53
maze-32-32-2	246±4	270±4	250±4	**278±5**	246±4	272±4	246±4	**274±3**
maze-32-32-4	228±6	**250±6**	234±6	**248±6**	224±5	**250±7**	232±6	**248±6**
maze-128-128-2	194±5	218±5	194±5	**232±4**	194±5	210±5	192±5	210±5
maze-128-128-10	366±12	416±10	376±11	**430±11**	374±11	410±12	376±11	414±12
maze	1,034±13	1,154±27	1,054±28	**1,188±28**	1,038±27	1,142±28	1,046±27	1,146±28
random-64-64-10	968±26	1,060±29	1,022±25	**1,108±30**	914±24	1,040±28	920±25	1,052±27
random-64-64-20	722±18	**790±18**	752±18	**810±21**	706±18	778±18	730±18	786±20
random-32-32-10	688±12	784±16	708±12	**824±16**	690±12	774±16	700±11	778±15
random-32-32-20	478±13	490±14	478±13	**518±15**	474±13	488±14	472±13	494±14
random	2,856±35	3,124±77	2,960±70	**3,260±84**	2,784±69	3,080±77	2,822±69	3,110±77
room-64-64-16	370±13	**418±14**	386±15	**416±16**	366±13	**414±14**	380±14	**410±15**
room-64-64-8	302±7	330±9	306±8	**342±10**	304±7	322±9	304±8	318±8
room-32-32-4	304±9	310±9	302±8	**324±9**	302±9	308±9	302±8	312±9
room	976 ±15	**1,058±33**	994 ±31	**1,082±36**	972 ±30	1,044±34	986 ±31	1,040±33
w-10-20-10-2-2	1,340±46	1,456±42	1,494±48	**1,596±35**	1,314±45	1,444±45	1,360±43	1,486±43
w-10-20-10-2-1	984±33	**1,004±32**	982±32	**1,022±35**	958±32	**1,028±33**	968±32	**1,012±33**
w-20-40-10-2-2	2,350±75	2,394±63	2,346±74	**2,546±71**	2,166±69	2,266±66	2,196±71	2,266±66
w-20-40-10-2-1	1,672±43	**1,796±44**	1,670±42	**1,762±41**	1,638±43	**1,778±43**	1,636±43	**1,786±43**
warehouse	6,346±99	6,650±183	6,492±198	**6,926±184**	6,076±191	6,516±188	6,160±191	6,550±186
Total	23,078±613	**25,634±618**	23,602±618	**26,546±641**	22,298±604	25,116±614	22,590±606	25,308±616

[1] Previous state-of-the-art.

Table 4: Total problems solved in under 30 seconds on 32-neighbor grid MAPF benchmarks

Map	CCBS With Bypass				CCBS Without Bypass			
	CCBS	DS	BC	KDB	CCBS	DS[1]	BC	KDB
Berlin_1_256	874±20	1,120±26	880±21	**1,206±31**	846±21	1,084±25	844±21	1,128±27
Boston_0_256	854±23	1,130±22	880±25	**1,242±24**	820±24	1,122±22	842±24	1,132±22
Paris_1_256	814±26	1,108±25	840±27	**1,232±25**	810±27	1,104±24	834±27	1,154±25
city	2,542±35	3,358±74	2,600±73	**3,680±81**	2,476±72	3,310±72	2,520±74	3,414±75
den520d	484±16	696±14	526±14	**726±17**	468±15	686±13	528±14	706±13
brc202d	404±13	498±11	420±12	**524±11**	412±13	514±12	428±13	**530±11**
den312d	432±9	544±9	446±10	**564±9**	426±9	528±9	438±10	550±10
lak303d	306±8	400±9	318±9	**432±9**	316±9	398±9	320±9	400±9
orz900d	240±8	302±7	252±8	**332±8**	246±8	300±7	256±8	304±7
ost003d	318±8	444±11	318±8	**480±11**	326±9	434±11	332±9	450±11
DAO	2,184±33	2,884±62	2,280±64	**3,058±67**	2,194±66	2,860±64	2,302±65	2,940±64
empty-16-16	410±10	540±13	428±9	**590±10**	410±10	540±10	430±10	552±12
empty-32-32	0±0	0±0	680±19	**956±19**	640±19	810±18	655±18	840±19
empty-48-48	858±18	1,130±25	918±19	**1,176±22**	866±21	1,066±24	880±20	1,098±24
empty-8-8	372±5	**388±5**	384±5	**394±6**	366±5	382±5	364±5	382±5
empty	1,640±17	2,058±43	2,410±54	**3,116±58**	2,282±57	2,798±59	2,329±55	2,872±60
lt_gallowstemplar_n	530±13	666±17	548±14	**682±15**	536±13	654±17	550±14	652±16
ht_chantry	452±12	568±13	468±12	**604±13**	436±13	570±14	458±13	588±15
ht_mansion_n	408±11	586±10	426±11	**612±10**	390±10	572±9	406±10	578±10
w_woundedcoast	322±8	398±8	332±8	**444±9**	320±8	394±7	324±8	406±8
DAO2	1,712±22	2,218±49	1,774±46	**2,342±49**	1,682±45	2,190±48	1,738±45	2,224±50
maze-32-32-2	214±4	262±4	220±3	**276±4**	214±4	260±4	218±3	264±4
maze-32-32-4	176±4	238±6	194±3	**264±6**	172±3	238±6	192±4	238±6
maze-128-128-2	148±5	194±4	160±5	**210±5**	148±5	196±4	166±5	198±4
maze-128-128-10	270±9	334±10	294±11	**374±9**	278±10	336±10	296±11	360±10
maze	808 ±11	1,028±26	868 ±24	**1,124±27**	812 ±23	1,030±26	872 ±23	1,060±26
random-64-64-10	774±18	966±18	822±20	**1,080±16**	770±18	968±19	816±19	1,010±20
random-64-64-20	610±11	720±15	638±13	**782±17**	610±11	706±14	634±13	734±16
random-32-32-10	604±15	696±13	628±16	**788±13**	590±15	686±13	622±16	702±13
random-32-32-20	438±13	484±12	446±12	**536±15**	434±13	480±12	444±12	494±12
random	2,426±29	2,866±60	2,534±63	**3,186±62**	2,404±58	2,840±59	2,516±61	2,940±63
room-64-64-16	322±8	408±12	348±8	**430±14**	322±8	402±11	342±8	408±12
room-64-64-8	274±7	324±8	278±7	**352±8**	274±7	322±8	278±7	320±7
room-32-32-4	304±9	310±9	302±8	**324±9**	302±9	308±9	302±8	312±9
room	900 ±12	1,042±30	928 ±24	**1,106±32**	898 ±25	1,032±29	922 ±24	1,040±29
w-10-20-10-2-2	1,096±28	1,294±29	1,124±27	**1,376±29**	1,040±28	1,208±29	1,076±28	1,244±28
w-10-20-10-2-1	982±32	**1,040±33**	980±32	**1,022±34**	958±30	**1,030±33**	962±30	**1,024±33**
w-20-40-10-2-2	1,822±55	2,084±57	1,888±58	**2,352±57**	1,742±51	1,974±50	1,812±56	2,036±56
w-20-40-10-2-1	1,582±34	**1,710±37**	1,596±35	**1,728±38**	1,578±33	1,620±36	1,582±33	1,622±36
warehouse	5,482±75	6,128±157	5,588±153	**6,478±160**	5,318±144	5,832±149	5,432±149	5,926±154
Total	17,694±473	21,582±505	18,982±504	**24,090±539**	18,066±493	21,892±512	18,631±501	22,416±524

[1] Previous state-of-the-art.

Table 5: Total problems solved in under 30 seconds on roadmaps

Map	CCBS With Bypass				CCBS Without Bypass			
	CCBS	DS	BC	KDB	CCBS	DS[1]	BC	KDB
sparse	396±7	434±9	400±7	**444±11**	396±8	434±9	404±8	**440±8**
dense	498±13	604±11	536±12	**712±12**	498±13	604±11	536±12	630±14
super-dense	272±10	402±11	318±10	**474±11**	272±10	402±11	318±10	442±11
Total	1,166±15	1,440±32	1,254±29	**1,630±36**	1,166±31	1,440±32	1,258±30	1,512±34

[1] Previous state-of-the-art.

3 Significance Testing Versus Previous State of the Art

The following tables show the p-values from results of significance testing using four tests:

- The paired T-Test, where pairs are the individual results (max number of agents solvable) for the 25 instances from each map.
- The Wilcoxon Ranked Sums test.
- The differential T-Test, where samples are the difference between pairs.
- The Wilcoxon Signed Rank test.

The T-Tests are for data that is normally distributed, or approximately so. The Wilcoxon tests are non-parametric, and likely more appropriate for this data set. The first two tests measure how similar the results are. The second two tests measure the magnitude of the difference between tests. The first two tests will tell us how much the two algorithms differ, e.g., whether one is stronger in certain maps than the other. The second two tests will tell us whether one algorithm significantly outperforms the other. The latter test does not report which algorithm is better, only the p-value that one is better. Thus it is required to state which algorithm has a higher total, this is indicated in the "Winner" column.

P-values of greater than 80% confidence are bold, p-values of greater than 95% confidence have and asterisk (*), p-values of greater than 99% confidence have two asterisks (**), p-values of greater than 99.9% confidence have three asterisks (***) and p-values of greater than 99.99% confidence have four asterisks (****).

Table 6: Significance Testing on 4-neighbor grid MAPF benchmarks

Map	Paired T-Test	Wilcoxon Ranked Sums	Differential T-Test	Wilcoxon Signed Rank Test	Winner
Berlin_1_256	0.5031	0.4669	**0.0914**	**0.0656**	BP+KDB
Boston_0_256	0.7792	0.7934	**0.0278***	**0.0412***	BP+KDB
Paris_1_256	0.6597	0.5475	**0.1141**	**0.0925**	BP+KDB
den520d	0.8403	0.869	**0.0898**	**0.1088**	BP+KDB
brc202d	0.7092	0.7489	0.2199	0.3499	BP+KDB
den312d	**0.1432**	**0.1595**	**0.0065****	**0.0114***	BP+KDB
lak303d	**0.1479**	**0.1327**	**0.0023****	**0.0036****	BP+KDB
orz900d	0.3776	0.5347	**0.1088**	**0.0986**	Base
ost003d	0.7991	0.7269	0.5461	0.5271	BP+KDB
empty-16-16	0.7396	0.7196	**0.0849**	**0.0235***	BP+KDB
empty-32-32	0.794	0.7342	0.3494	0.2476	BP+KDB
empty-48-48	0.4946	0.5157	**0.0158***	**0.0143***	BP+KDB
empty-8-8	0.3851	0.332	**0.1023**	**0.0679**	BP+KDB
lt_gallowstemplar_n	0.7078	0.7342	**0.0504**	**0.0412***	BP+KDB
ht_chantry	0.7119	0.6415	0.2623	**0.1228**	BP+KDB
ht_mansion_n	0.3459	0.3826	**0.0125***	**0.0167***	BP+KDB
w_woundedcoast	0.5636	0.5869	**0.0298***	**0.0206***	BP+KDB
maze-32-32-2	0.9267	0.8996	0.8659	0.586	Base
maze-32-32-4	0.9425	0.9459	0.7463	0.7855	BP+KDB
maze-128-128-2	0.7341	0.8234	0.2124	0.2059	BP+KDB
maze-128-128-10	0.6307	0.6415	**0.0863**	**0.0928**	BP+KDB
random-64-64-10	0.6958	0.7196	0.2191	**0.1088**	BP+KDB
random-64-64-20	0.6157	0.6276	**0.1078**	**0.1064**	BP+KDB
random-32-32-10	0.5298	0.5737	**0.1536**	**0.1408**	BP+KDB
random-32-32-20	0.7079	0.7636	**0.13**	**0.1441**	BP+KDB
room-64-64-16	0.9443	0.892	0.7645	0.4386	BP+KDB
room-64-64-8	0.5225	0.4609	**0.0559**	**0.0619**	BP+KDB
room-32-32-4	0.6497	0.6695	**0.0863**	**0.1025**	BP+KDB
w-10-20-10-2-2	0.2192	0.4551	**0.066**	**0.0464***	BP+KDB
w-10-20-10-2-1	0.7651	0.7415	0.2992	**0.1755**	BP+KDB
w-20-40-10-2-2	0.6349	0.6624	0.2918	0.285	BP+KDB
w-20-40-10-2-1	**0.0842**	**0.1229**	**0.0144***	**0.0049****	BP+KDB

Table 7: Significance Testing on 8-neighbor grid MAPF benchmarks

Map	Paired T-Test	Wilcoxon Ranked Sums	Differential T-Test	Wilcoxon Signed Rank Test	Winner
Berlin_1_256	0.9608	0.8996	0.7589	0.6219	BP+KDB
Boston_0_256	0.6977	0.522	**0.1124**	**0.0646**	BP+KDB
Paris_1_256	0.3417	0.273	**0.0077****	**0.0107***	BP+KDB
den520d	0.7574	0.6345	0.2387	0.2456	BP+KDB
brc202d	0.517	0.5157	**0.1367**	**0.0385***	BP+KDB
den312d	1.0	0.969	1.0	0.6304	BP+KDB
lak303d	0.4628	0.4492	**0.0571**	**0.0606**	BP+KDB
orz900d	0.5351	0.5936	**0.01***	**0.0066****	BP+KDB
ost003d	0.7046	0.8084	**0.1942**	0.2359	BP+KDB
empty-16-16	0.4905	0.4669	**0.154**	**0.1326**	BP+KDB
empty-32-32	**0.1088**	**0.1377**	**0.0045****	**0.0051****	BP+KDB
empty-48-48	0.4597	0.4551	**0.0266***	**0.0379***	BP+KDB
empty-8-8	0.3866	0.4151	**0.1704**	**0.1813**	BP+KDB
lt_gallowstemplar_n	0.5274	0.5803	0.2528	0.2052	BP+KDB
ht_chantry	0.4862	0.3721	**0.1924**	0.2857	BP+KDB
ht_mansion_n	**0.1689**	**0.1775**	**0.0031****	**0.0022****	BP+KDB
w_woundedcoast	0.9068	0.8009	0.6489	0.8104	BP+KDB
maze-32-32-2	1.0	0.9845	1.0	0.927	BP+KDB
maze-32-32-4	0.6726	0.7342	**0.1659**	**0.1797**	BP+KDB
maze-128-128-2	0.94	0.8538	0.6639	0.6547	BP+KDB
maze-128-128-10	0.7091	0.7196	**0.1185**	**0.1201**	BP+KDB
random-64-64-10	**0.0877**	**0.056**	**0.0225***	**0.0207***	BP+KDB
random-64-64-20	0.7749	0.698	0.5532	0.9438	BP+KDB
random-32-32-10	0.2813	0.2948	**0.0687**	**0.0388***	BP+KDB
random-32-32-20	0.9022	0.9536	0.6886	0.715	Base
room-64-64-16	0.662	0.7124	0.2328	0.2311	BP+KDB
room-64-64-8	0.8522	0.9227	0.4781	0.5176	Base
room-32-32-4	0.8075	0.7342	0.2563	0.2342	BP+KDB
w-10-20-10-2-2	**0.1251**	**0.0952**	**0.0109***	**0.0074****	BP+KDB
w-10-20-10-2-1	0.7882	0.7636	**0.1562**	0.2059	BP+KDB
w-20-40-10-2-2	0.4068	0.3879	**0.0429***	**0.0376***	BP+KDB
w-20-40-10-2-1	0.7663	0.7269	0.2065	0.2396	BP+KDB

Table 8: Significance Testing on 16-neighbor grid MAPF benchmarks

Map	Paired T-Test	Wilcoxon Ranked Sums	Differential T-Test	Wilcoxon Signed Rank Test	Winner
Berlin_1_256	**0.0685**	**0.0743**	**0.0049****	**0.0083****	BP+KDB
Boston_0_256	1.0	0.9923	1.0	0.5907	BP+KDB
Paris_1_256	0.5821	0.3826	0.3445	0.3838	BP+KDB
den520d	0.4394	0.3084	**0.1244**	**0.1194**	BP+KDB
brc202d	0.6521	0.5475	**0.1869**	0.2031	BP+KDB
den312d	0.4051	0.2687	**0.0649**	**0.0719**	BP+KDB
lak303d	0.3106	0.4263	**0.012***	**0.0033****	BP+KDB
orz900d	0.4787	0.3933	**0.0504**	**0.056**	BP+KDB
ost003d	0.6316	0.6695	**0.1335**	**0.1646**	BP+KDB
empty-16-16	0.2535	0.2003	**0.0106***	**0.0088****	BP+KDB
empty-32-32	0.7115	0.7124	0.4363	0.2935	BP+KDB
empty-48-48	0.7487	0.8009	0.4326	0.3809	BP+KDB
empty-8-8	0.5617	0.6004	0.2822	0.2098	BP+KDB
lt_gallowstemplar_n	0.2971	0.3272	**0.0124***	**0.0072****	BP+KDB
ht_chantry	0.7914	0.7859	0.2153	**0.0638**	BP+KDB
ht_mansion_n	0.3424	0.3038	**0.0202***	**0.0176***	BP+KDB
w_woundedcoast	**0.12**	**0.1183**	**0.0054****	**0.0053****	BP+KDB
maze-32-32-2	0.7275	0.6908	0.6116	0.5827	BP+KDB
maze-32-32-4	0.935	0.9923	0.7463	0.7855	Base
maze-128-128-2	0.2447	0.4492	**0.0311***	**0.0414***	BP+KDB
maze-128-128-10	0.6425	0.7489	0.218	**0.1948**	BP+KDB
random-64-64-10	0.5266	0.4151	**0.0249***	**0.0178***	BP+KDB
random-64-64-20	0.661	0.7269	**0.1942**	0.2115	BP+KDB
random-32-32-10	0.399	0.4096	**0.1178**	**0.1376**	BP+KDB
random-32-32-20	0.5812	0.522	**0.1177**	**0.1361**	BP+KDB
room-64-64-16	0.9723	0.892	0.9152	0.8878	BP+KDB
room-64-64-8	0.5777	0.522	**0.0475***	**0.0473***	BP+KDB
room-32-32-4	0.6449	0.5869	**0.1185**	**0.1025**	BP+KDB
w-10-20-10-2-2	0.3082	0.3933	**0.0409***	**0.0374***	BP+KDB
w-10-20-10-2-1	0.9615	0.9768	0.8845	1.0	Base
w-20-40-10-2-2	0.2677	0.332	**0.0944**	**0.0992**	BP+KDB
w-20-40-10-2-1	0.9172	0.7562	0.7368	0.7529	Base

Table 9: Significance Testing on 32-neighbor grid MAPF benchmarks

Map	Paired T-Test	Wilcoxon Ranked Sums	Differential T-Test	Wilcoxon Signed Rank Test	Winner
Berlin_1_256	0.2455	0.2483	**0.0046****	**0.0005*****	BP+KDB
Boston_0_256	**0.1625**	**0.1403**	**0.0034****	**0.003****	BP+KDB
Paris_1_256	**0.1668**	**0.0991**	**0.0009*****	**0.001****	BP+KDB
den520d	0.4764	0.4971	**0.0912**	**0.0448***	BP+KDB
brc202d	0.8213	0.7934	0.5261	0.53	BP+KDB
den312d	0.3016	0.332	**0.0167***	**0.0139***	BP+KDB
lak303d	0.3251	0.2687	**0.003****	**0.0049****	BP+KDB
orz900d	0.2822	0.3721	**0.0011****	**0.0025****	BP+KDB
ost003d	0.2733	0.2687	**0.0068****	**0.0087****	BP+KDB
empty-16-16	0.2029	**0.116**	**0.0009*****	**0.0018****	BP+KDB
empty-32-32	**0.037***	**0.0336***	**0.0003*****	**0.0001*****	BP+KDB
empty-48-48	**0.199**	0.2038	**0.005****	**0.0077****	BP+KDB
empty-8-8	0.5976	0.5283	**0.185**	**0.1927**	BP+KDB
lt_gallowstemplar_n	0.6365	0.9073	0.309	0.3723	BP+KDB
ht_chantry	0.5046	0.4609	0.2023	**0.022***	BP+KDB
ht_mansion_n	0.2837	0.2143	**0.002****	**0.0028****	BP+KDB
w_woundedcoast	**0.1108**	**0.1206**	**0.0024****	**0.0011****	BP+KDB
maze-32-32-2	0.3543	0.4492	**0.1476**	**0.1356**	BP+KDB
maze-32-32-4	0.283	0.2903	**0.0065****	**0.0103***	BP+KDB
maze-128-128-2	0.4627	0.5737	**0.05**	**0.0532**	BP+KDB
maze-128-128-10	0.3086	**0.1429**	**0.0019****	**0.0035****	BP+KDB
random-64-64-10	**0.0857**	**0.0933**	**0.0006*****	**0.0004*****	BP+KDB
random-64-64-20	**0.1944**	0.2563	**0.0074****	**0.0101***	BP+KDB
random-32-32-10	**0.0406***	**0.0727**	**0.0028****	**0.0023****	BP+KDB
random-32-32-20	0.281	0.2108	**0.0245***	**0.0227***	BP+KDB
room-64-64-16	0.5603	0.7342	**0.0452***	**0.0473***	BP+KDB
room-64-64-8	0.3343	0.3224	**0.0105***	**0.0109***	BP+KDB
room-32-32-4	0.6449	0.5869	**0.1185**	**0.1025**	BP+KDB
w-10-20-10-2-2	**0.1218**	**0.1229**	**0.0023****	**0.0026****	BP+KDB
w-10-20-10-2-1	0.9481	0.9768	0.7512	0.9049	Base
w-20-40-10-2-2	**0.0598**	**0.0991**	**0.0058****	**0.0038****	BP+KDB
w-20-40-10-2-1	0.4278	0.3618	**0.1131**	**0.0452***	BP+KDB

Table 10: Significance Testing on roadmap benchmarks

Map	Paired T-Test	Wilcoxon Ranked Sums	Differential T-Test	Wilcoxon Signed Rank Test	Winner
sparse	0.791	0.6484	0.6252	0.8541	BP+KDB
dense	**0.0199***	**0.0157***	**0.0****	**0.0****	BP+KDB
super-dense	**0.0914**	**0.0842**	**0.0013****	**0.0008*****	BP+KDB