Lista 1

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1. Introdução

Nossa implementação dos algoritmos foi feita na linguagem C++. Além do arquivo main.cpp, organizamos o código em outros dois arquivos: state.cpp, que implementa uma classe que representa um estado do problema 8 puzzle ou 15 puzzle, e search.cpp, que implementa os algoritmos de busca. Baseamos os algoritmos em uma função de busca em grafos generalizada, onde executando um algoritmo mudamos apenas a estrutura de dados da fronteira de busca, e implementamos as filas ou listas de prioridades de cada algoritmo. Dessa forma pudemos facilitar a adição de novos algoritmos no programa, mantendo as mesmas entradas e saídas esperadas. A performance de execução das instâncias de 8 puzzle foi bastante satisfatória, porém para as instâncias de 15 puzzle o programa consumiu bastante tempo e espaço de memória. Acreditamos que, em troca da generalização de código que acelerou a implementação, perdemos em questão da otimização de espaço, e para instâncias do problema 15 puzzle o conjunto de estados expandidos cresceu além do que esperávamos.

2. Resultados

O código-fonte foi compilado usando o compilador de C++ GNU (g++ 11.3.0), em um subsistema Ubuntu 22.04 operando sob um sistema Windows 10. A máquina da execução possuía uma CPU AMD Ryzen 3 3200G de 3.6 GHz, e 16 GB de memória RAM. Para cada algoritmo todas as instâncias de 8-puzzle ou 15-puzzle foram executadas uma vez, e os resultados foram armazenados em um arquivo CSV. O comando utilizado para executar o programa em todas as instancias foi `xargs -a ./15puzzle_instances.txt -I{} -d'\n' ./main -astar {} > 15puzzle-astar.csv` . Na tabela a seguir apresentamos as médias das métricas calculadas para cada algoritmo. Em seguida apresentamos todos os resultados de cada instância para cada algoritmo.

Algoritmo	**Nº Nodos**	**Tamanho Solução**	**Tempo (s)**	**Média h(s)**	**h(s) Inicial**
BFS-Graph	96822,81	22,16	0,297441106	0	13,88
Iterative Deepening	2578290,56	22,16	1,762869684	0	13,88
A*	895	22,16	0,005994317	10,0277522	13,88
IDA*	2373,03	22,16	0,005752111	10,4150672	13,88
GBFS	392,42	140,52	0,003469548	6,8930464	13,88
A* (15-puzzle)	999.999	999.999	999.999	999.999	999.999

2.1. BFS-Graph

Instância	Nº Nodos	Tamanho Solução	Tempo (s)	Média h(s)	h(s) Inicial
5 6 2 7 1 8 3 4 0	93951	22	0.261613	0	12
5 3 2 8 7 1 4 0 6	123504	23	0.373399	0	15
1 0 7 5 2 4 3 8 6	18358	17	0.0483891	0	13
3 6 4 2 8 0 5 7 1	153815	25	0.483433	0	17
0 6 1 7 4 2 3 8 5	8091	16	0.0203725	0	10
0 3 8 2 1 4 7 6 5	79330	22	0.226127	0	12
0 8 2 1 5 6 7 3 4	95508	22	0.270678	0	14
5 0 2 6 4 8 1 7 3	57523	21	0.148105	0	11
3 0 8 4 1 2 6 7 5	16215	17	0.0362638	0	7
7 2 6 3 1 5 8 0 4	76055	21	0.205715	0	13
2 4 7 0 3 6 8 1 5	108411	23	0.320769	0	15
2 1 6 0 4 3 7 5 8	110531	23	0.318948	0	11
1 2 8 0 3 7 5 6 4	35593	19	0.0906815	0	13
1 4 8 2 7 6 0 3 5	90101	22	0.258388	0	14
5 0 2 1 6 8 7 3 4	30755	19	0.0750007	0	13
6 2 1 5 0 4 3 8 7	88646	22	0.24196	0	10
1 8 0 4 5 2 6 7 3	44333	20	0.111574	0	10
7 6 4 8 1 3 5 0 2	71188	21	0.194439	0	19
1 8 7 5 0 4 2 3 6	96969	22	0.276908	0	18
2 8 0 4 1 7 5 6 3	75461	22	0.206244	0	16
7 8 1 3 6 2 4 5 0	9822	16	0.0223911	0	14
1 4 7 3 6 2 0 8 5	7506	16	0.0167237	0	10
5 2 3 4 7 1 8 0 6	146862	25	0.446514	0	15
5 1 3 2 6 4 7 8 0	78321	22	0.210391	0	14
1 0 2 5 8 6 4 7 3	108119	23	0.316069	0	13
4 7 6 0 5 2 3 8 1	142700	25	0.503624	0	15
5 8 2 1 7 6 3 0 4	76938	21	0.207015	0	15
3 0 2 6 1 4 5 7 8	3152	13	0.00593533	0	7
2 0 1 7 5 3 8 6 4	112299	23	0.323734	0	13
8 1 0 5 3 7 2 4 6	116500	24	0.346984	0	16
0 2 6 5 4 7 1 3 8	132349	24	0.403575	0	14
4 5 0 1 7 2 3 8 6	10921	16	0.0248017	0	12
0 6 3 5 8 2 1 7 4	18235	18	0.0413724	0	16
1 4 8 0 7 5 2 6 3	114780	23	0.33962	0	13
1 5 0 8 4 3 2 7 6	162420	26	0.53299	0	14
2 3 6 8 1 0 5 4 7	175106	27	0.609055	0	17
1 6 0 7 3 8 4 5 2	82544	22	0.220334	0	14
8 4 3 1 6 5 0 7 2	164767	26	0.542922	0	14
3 8 2 7 5 1 0 6 4	88723	22	0.247282	0	12
7 2 3 6 4 8 1 0 5	154075	25	0.483015	0	13
3 1 2 4 0 8 5 7 6	5770	14	0.0138685	0	8
8 5 3 1 2 6 4 0 7	160146	25	0.504227	0	19
2 0 8 6 1 3 4 7 5	70358	21	0.235361	0	11

3 6 7 1 2 8 4 5 0	163034	26	0.520579	0	16
0 3 6 1 2 8 4 7 5	117096	24	0.343579	0	14
4 8 6 5 0 7 1 3 2	139640	24	0.425949	0	20
7 2 0 1 8 6 3 4 5	19077	18	0.0449588	0	14
4 0 7 1 3 2 5 8 6	103415	23	0.307036	0	15
1 4 3 0 5 8 7 6 2	77105	21	0.220028	0	11
1 3 6 5 8 4 0 2 7	176601	28	0.582989	0	16
3 1 6 4 0 8 7 5 2	58485	20	0.15102	0	12
8 0 5 1 4 3 7 2 6	173180	27	0.575232	0	15
1 0 2 8 7 3 4 6 5	38364	19	0.0996037	0	11
5 8 1 4 7 3 2 6 0	162247	26	0.521387	0	16
6 4 1 2 0 3 7 8 5	24847	18	0.0579195	0	12
6 1 7 4 8 3 5 2 0	137252	24	0.423687	0	16
0 1 5 3 8 7 6 4 2	19149	18	0.0447462	0	8
7 8 2 6 4 3 0 1 5	124541	24	0.371043	0	12
6 0 8 7 4 3 5 2 1	115212	23	0.332973	0	17
5 4 0 7 6 2 8 3 1	140070	24	0.439211	0	16
5 6 1 8 7 0 2 4 3	178344	27	0.589518	0	19
1 6 7 4 2 0 3 5 8	151453	25	0.476136	0	13
5 3 6 4 7 2 1 0 8	58947	21	0.153636	0	15
0 8 7 4 2 6 1 3 5	81619	22	0.226535	0	18
7 2 0 5 4 3 8 6 1	178582	28	0.591799	0	14
5 3 0 6 7 1 8 2 4	54081	20	0.133236	0	16
5 7 2 8 3 6 4 0 1	175545	27	0.582037	0	17
3 7 8 1 4 6 5 0 2	174768	27	0.586457	0	15
7 4 5 8 6 3 2 0 1	155458	25	0.492851	0	19
0 4 1 8 2 5 3 7 6	123201	24	0.360532	0	10
5 1 7 2 3 6 8 4 0	120555	24	0.360462	0	16
6 3 4 8 2 1 5 7 0	92950	22	0.266028	0	16
2 0 1 5 7 6 4 8 3	177234	27	0.582484	0	15
7 8 0 6 3 1 2 5 4	162390	26	0.537605	0	18
6 2 4 3 7 0 5 1 8	155966	25	0.485106	0	11
7 5 4 8 3 6 0 2 1	159969	26	0.515426	0	20
3 8 4 5 7 1 0 6 2	46329	20	0.117447	0	14
5 6 2 8 7 1 0 3 4	165168	26	0.525763	0	16
3 2 4 6 5 8 0 7 1	10947	16	0.0252427	0	10
7 5 1 6 8 4 2 0 3	174576	27	0.579553	0	17
3 5 2 0 8 1 4 6 7	28755	19	0.0725479	0	11
8 0 6 7 1 3 5 2 4	153336	25	0.505295	0	21
2 5 8 4 1 0 6 3 7	5361	15	0.0117893	0	11
7 0 2 1 8 6 3 4 5	14405	17	0.042266	0	13
2 1 5 3 8 0 6 7 4	6339	15	0.0160058	0	7
3 8 6 4 7 0 1 5 2	153573	25	0.481207	0	17
1 0 7 2 4 3 6 8 5	17029	17	0.0383254	0	11
3 6 7 5 8 0 4 1 2	174375	27	0.569908	0	17
6 2 0 3 1 4 8 7 5	46324	20	0.113493	0	8
7 1 5 4 0 3 2 6 8	52037	20	0.134896	0	12

8 0 7 4 6 1 5 2 3	173101	27	0.590739	0	21
8 2 0 5 7 6 1 3 4	160790	26	0.632921	0	18
3 8 5 7 0 1 6 4 2	89826	22	0.274441	0	12
3 5 4 1 7 6 0 2 8	92356	22	0.28689	0	14
0 2 8 5 4 1 7 3 6	88256	22	0.257032	0	12
4 3 7 0 6 1 5 8 2	37732	19	0.1043	0	17
2 1 3 4 6 5 0 7 8	43663	20	0.116575	0	8
1 0 5 4 6 2 7 3 8	61655	21	0.179379	0	9
7 2 3 1 5 4 8 6 0	129705	24	0.414258	0	14
5 7 2 6 4 0 8 3 1	149515	25	0.485235	0	13

2.2. Iterative Deepening

Instância	Nº Nodos	Tamanho Solução	Tempo (s)	Média h(s)	h(s) Inicial
5 6 2 7 1 8 3 4 0	809224	22	0.701186	0	12
5 3 2 8 7 1 4 0 6	1659716	23	1.17494	0	15
1 0 7 5 2 4 3 8 6	56332	17	0.0579092	0	13
3 6 4 2 8 0 5 7 1	3832745	25	2.55891	0	17
0 6 1 7 4 2 3 8 5	20305	16	0.0121092	0	10
0 3 8 2 1 4 7 6 5	572929	22	0.37373	0	12
0 8 2 1 5 6 7 3 4	840836	22	0.546471	0	14
5 0 2 6 4 8 1 7 3	336804	21	0.229025	0	11
3 0 8 4 1 2 6 7 5	48030	17	0.0313428	0	7
7 2 6 3 1 5 8 0 4	523656	21	0.337337	0	13
2 4 7 0 3 6 8 1 5	1183127	23	0.803384	0	15
2 1 6 0 4 3 7 5 8	1229083	23	0.829844	0	11
1 2 8 0 3 7 5 6 4	144153	19	0.0982717	0	13
1 4 8 2 7 6 0 3 5	726908	22	0.471912	0	14
5 0 2 1 6 8 7 3 4	119854	19	0.0777288	0	13
6 2 1 5 0 4 3 8 7	746437	22	0.506642	0	10
1 8 0 4 5 2 6 7 3	201422	20	0.1328	0	10
7 6 4 8 1 3 5 0 2	463439	21	0.30167	0	19
1 8 7 5 0 4 2 3 6	880730	22	0.580798	0	18
2 8 0 4 1 7 5 6 3	529433	22	0.348014	0	16
7 8 1 3 6 2 4 5 0	25389	16	0.0166783	0	14
1 4 7 3 6 2 0 8 5	18803	16	0.0113878	0	10
5 2 3 4 7 1 8 0 6	3233556	25	2.20479	0	15
5 1 3 2 6 4 7 8 0	559966	22	0.375479	0	14
1 0 2 5 8 6 4 7 3	1161412	23	0.757709	0	13
4 7 6 0 5 2 3 8 1	3012022	25	2.02977	0	15
5 8 2 1 7 6 3 0 4	533665	21	0.358753	0	15
3 0 2 6 1 4 5 7 8	6472	13	0.00395877	0	7
2 0 1 7 5 3 8 6 4	1258485	23	0.824568	0	13
8 1 0 5 3 7 2 4 6	1506581	24	1.00613	0	16
0 2 6 5 4 7 1 3 8	2082556	24	1.42213	0	14
4 5 0 1 7 2 3 8 6	28816	16	0.0172882	0	12

0 6 3 5 8 2 1 7 4	57963	18	0.0375647	0	16
1 4 8 0 7 5 2 6 3	1339032	23	0.897319	0	13
1 5 0 8 4 3 2 7 6	5227219	26	3.57637	0	14
2 3 6 8 1 0 5 4 7	10582097	27	7.24926	0	17
1 6 0 7 3 8 4 5 2	618550	22	0.41175	0	14
8 4 3 1 6 5 0 7 2	5647709	26	3.73482	0	14
3 8 2 7 5 1 0 6 4	707091	22	0.459845	0	12
7 2 3 6 4 8 1 0 5	3906491	25	2.63407	0	13
3 1 2 4 0 8 5 7 6	13166	14	0.00836843	0	8
8 5 3 1 2 6 4 0 7	4826279	25	3.28416	0	19
2 0 8 6 1 3 4 7 5	445186	21	0.294901	0	11
3 6 7 1 2 8 4 5 0	5301125	26	3.56603	0	16
0 3 6 1 2 8 4 7 5	1521264	24	1.00731	0	14
4 8 6 5 0 7 1 3 2	2550556	24	1.81928	0	20
7 2 0 1 8 6 3 4 5	60744	18	0.0378721	0	14
4 0 7 1 3 2 5 8 6	1071876	23	0.707414	0	15
1 4 3 0 5 8 7 6 2	542261	21	0.35618	0	11
1 3 6 5 8 4 0 2 7	13426501	28	8.94039	0	16
3 1 6 4 0 8 7 5 2	323493	20	0.215581	0	12
8 0 5 1 4 3 7 2 6	9617303	27	6.40737	0	15
1 0 2 8 7 3 4 6 5	160297	19	0.107652	0	11
5 8 1 4 7 3 2 6 0	5150682	26	3.38857	0	16
6 4 1 2 0 3 7 8 5	86884	18	0.0568507	0	12
6 1 7 4 8 3 5 2 0	2296791	24	1.56556	0	16
0 1 5 3 8 7 6 4 2	60654	18	0.0399099	0	8
7 8 2 6 4 3 0 1 5	1715624	24	1.17539	0	12
6 0 8 7 4 3 5 2 1	1336827	23	0.895757	0	17
5 4 0 7 6 2 8 3 1	2536222	24	1.72852	0	16
5 6 1 8 7 0 2 4 3	15171649	27	10.4281	0	19
1 6 7 4 2 0 3 5 8	3587527	25	2.38498	0	13
5 3 6 4 7 2 1 0 8	344582	21	0.348165	0	15
0 8 7 4 2 6 1 3 5	599226	22	0.440176	0	18
7 2 0 5 4 3 8 6 1	15073854	28	10.6744	0	14
5 3 0 6 7 1 8 2 4	277227	20	0.193003	0	16
5 7 2 8 3 6 4 0 1	10843669	27	7.53782	0	17
3 7 8 1 4 6 5 0 2	10295974	27	7.10116	0	15
7 4 5 8 6 3 2 0 1	4095213	25	2.82992	0	19
0 4 1 8 2 5 3 7 6	1665813	24	1.14445	0	10
5 1 7 2 3 6 8 4 0	1583030	24	1.16141	0	16
6 3 4 8 2 1 5 7 0	792904	22	0.538129	0	16
2 0 1 5 7 6 4 8 3	12496979	27	8.77031	0	15
7 8 0 6 3 1 2 5 4	5225955	26	3.5895	0	18
6 2 4 3 7 0 5 1 8	4088312	25	2.83126	0	11
7 5 4 8 3 6 0 2 1	4873453	26	3.29771	0	20
3 8 4 5 7 1 0 6 2	214527	20	0.143295	0	14

5 6 2 8 7 1 0 3 4	5735592	26	3.86597	0	16
3 2 4 6 5 8 0 7 1	28881	16	0.0178394	0	10
7 5 1 6 8 4 2 0 3	10128430	27	6.82132	0	17
3 5 2 0 8 1 4 6 7	110829	19	0.0795015	0	11
8 0 6 7 1 3 5 2 4	3745531	25	2.53034	0	21
2 5 8 4 1 0 6 3 7	12608	15	0.00788014	0	11
7 0 2 1 8 6 3 4 5	42323	17	0.0309883	0	13
2 1 5 3 8 0 6 7 4	15054	15	0.00941797	0	7
3 8 6 4 7 0 1 5 2	3814064	25	2.69222	0	17
1 0 7 2 4 3 6 8 5	51080	17	0.0363675	0	11
3 6 7 5 8 0 4 1 2	10083429	27	6.91349	0	17
6 2 0 3 1 4 8 7 5	216000	20	0.147771	0	8
7 1 5 4 0 3 2 6 8	269408	20	0.182989	0	12
8 0 7 4 6 1 5 2 3	9608157	27	6.53392	0	21
8 2 0 5 7 6 1 3 4	4963354	26	3.55748	0	18
3 8 5 7 0 1 6 4 2	761900	22	0.540056	0	12
3 5 4 1 7 6 0 2 8	779904	22	0.529012	0	14
0 2 8 5 4 1 7 3 6	713444	22	0.492913	0	12
4 3 7 0 6 1 5 8 2	156601	19	0.104727	0	17
2 1 3 4 6 5 0 7 8	197513	20	0.132563	0	8
1 0 5 4 6 2 7 3 8	365116	21	0.239613	0	9
7 2 3 1 5 4 8 6 0	1905883	24	1.26558	0	14
5 7 2 6 4 0 8 3 1	3411288	25	2.33449	0	13

2.3. A*

Instância	Nº Nodos	Tamanho Solução	Tempo (s)	Média h(s)	h(s) Inicial
5 6 2 7 1 8 3 4 0	835	22	0.00637092	9.08244	12
5 3 2 8 7 1 4 0 6	1024	23	0.00603687	10.0667	15
1 0 7 5 2 4 3 8 6	72	17	0.000455004	9.15079	13
3 6 4 2 8 0 5 7 1	953	25	0.00539422	11.6783	17
0 6 1 7 4 2 3 8 5	91	16	0.000581658	6.72561	10
0 3 8 2 1 4 7 6 5	652	22	0.00489703	9.37182	12
0 8 2 1 5 6 7 3 4	350	22	0.00175268	10.4395	14
5 0 2 6 4 8 1 7 3	612	21	0.00341195	9.81136	11
3 0 8 4 1 2 6 7 5	232	17	0.00106455	7.8625	7
7 2 6 3 1 5 8 0 4	177	21	0.00119306	10.8271	13
2 4 7 0 3 6 8 1 5	511	23	0.00371225	9.97655	15
2 1 6 0 4 3 7 5 8	1037	23	0.00603316	10.3864	11
1 2 8 0 3 7 5 6 4	197	19	0.000937909	8.38938	13
1 4 8 2 7 6 0 3 5	697	22	0.00520573	9.28096	14
5 0 2 1 6 8 7 3 4	239	19	0.00116379	7.90571	13
6 2 1 5 0 4 3 8 7	1622	22	0.010179	9.72591	10
1 8 0 4 5 2 6 7 3	315	20	0.00209357	8.87339	10
7 6 4 8 1 3 5 0 2	30	21	0.000119644	10.3269	19

1 8 7 5 0 4 2 3 6	373	22	0.00197931	10.5618	18
2 8 0 4 1 7 5 6 3	550	22	0.00294305	10.553	16
7 8 1 3 6 2 4 5 0	34	16	0.000149844	8.22951	14
1 4 7 3 6 2 0 8 5	118	16	0.000553907	8.47549	10
5 2 3 4 7 1 8 0 6	1449	25	0.00860412	10.8645	15
5 1 3 2 6 4 7 8 0	873	22	0.00595674	10.0839	14
1 0 2 5 8 6 4 7 3	808	23	0.00469431	9.78436	13
4 7 6 0 5 2 3 8 1	1167	25	0.0080853	10.5056	15
5 8 2 1 7 6 3 0 4	308	21	0.00223465	9.42476	15
3 0 2 6 1 4 5 7 8	41	13	0.000168995	6.08	7
2 0 1 7 5 3 8 6 4	533	23	0.0029237	11.0371	13
8 1 0 5 3 7 2 4 6	346	24	0.00182358	11.5	16
0 2 6 5 4 7 1 3 8	929	24	0.0079263	10.2885	14
4 5 0 1 7 2 3 8 6	117	16	0.00064895	8.69951	12
0 6 3 5 8 2 1 7 4	26	18	0.000109664	9.02083	16
1 4 8 0 7 5 2 6 3	666	23	0.00360041	10.136	13
1 5 0 8 4 3 2 7 6	1734	26	0.0131332	10.7851	14
2 3 6 8 1 0 5 4 7	1824	27	0.0141974	12.1416	17
1 6 0 7 3 8 4 5 2	231	22	0.00111673	11.4182	14
8 4 3 1 6 5 0 7 2	1807	26	0.0139244	10.7077	14
3 8 2 7 5 1 0 6 4	655	22	0.00547747	9.45545	12
7 2 3 6 4 8 1 0 5	2298	25	0.0148082	10.2244	13
3 1 2 4 0 8 5 7 6	76	14	0.00031097	7.45185	8
8 5 3 1 2 6 4 0 7	786	25	0.00430072	11.2696	19
2 0 8 6 1 3 4 7 5	609	21	0.00330583	9.22804	11
3 6 7 1 2 8 4 5 0	2231	26	0.014254	10.6504	16
0 3 6 1 2 8 4 7 5	1757	24	0.0113274	9.85137	14
4 8 6 5 0 7 1 3 2	299	24	0.0015499	11.503	20
7 2 0 1 8 6 3 4 5	41	18	0.000293039	9.95946	14
4 0 7 1 3 2 5 8 6	543	23	0.00430104	10.6895	15
1 4 3 0 5 8 7 6 2	438	21	0.00233811	10.0621	11
1 3 6 5 8 4 0 2 7	2864	28	0.0200773	12.2559	16
3 1 6 4 0 8 7 5 2	221	20	0.00106024	9.78497	12
8 0 5 1 4 3 7 2 6	2849	27	0.0215001	11.0714	15
1 0 2 8 7 3 4 6 5	179	19	0.000828376	8.82792	11
5 8 1 4 7 3 2 6 0	1075	26	0.00638873	11.5799	16
6 4 1 2 0 3 7 8 5	177	18	0.000827815	8.58117	12
6 1 7 4 8 3 5 2 0	752	24	0.00428358	10.0917	16
0 1 5 3 8 7 6 4 2	182	18	0.000906398	8.1865	8
7 8 2 6 4 3 0 1 5	1355	24	0.00817329	10.0853	12
6 0 8 7 4 3 5 2 1	205	23	0.000992811	11.0603	17
5 4 0 7 6 2 8 3 1	712	24	0.00390517	10.5858	16
5 6 1 8 7 0 2 4 3	1421	27	0.0106237	12.0228	19
1 6 7 4 2 0 3 5 8	2186	25	0.0161903	9.91612	13
5 3 6 4 7 2 1 0 8	168	21	0.00098134	10.6818	15
0 8 7 4 2 6 1 3 5	39	22	0.000210236	12.0147	18

7 2 0 5 4 3 8 6 1	4038	28	0.030722	11.1541	14
5 3 0 6 7 1 8 2 4	90	20	0.000590068	9.61688	16
5 7 2 8 3 6 4 0 1	2905	27	0.0227237	10.8626	17
3 7 8 1 4 6 5 0 2	2301	27	0.0167011	11.8772	15
7 4 5 8 6 3 2 0 1	698	25	0.00584122	10.8711	19
0 4 1 8 2 5 3 7 6	2190	24	0.0140356	9.48527	10
5 1 7 2 3 6 8 4 0	936	24	0.00543779	11.8384	16
6 3 4 8 2 1 5 7 0	238	22	0.00115384	9.92629	16
2 0 1 5 7 6 4 8 3	3038	27	0.0203035	10.957	15
7 8 0 6 3 1 2 5 4	1632	26	0.0123027	10.8184	18
6 2 4 3 7 0 5 1 8	4306	25	0.032275	10.3003	11
7 5 4 8 3 6 0 2 1	739	26	0.00502198	11.9036	20
3 8 4 5 7 1 0 6 2	382	20	0.0026641	9.36435	14
5 6 2 8 7 1 0 3 4	2084	26	0.0150282	10.7022	16
3 2 4 6 5 8 0 7 1	99	16	0.000573127	7.52841	10
7 5 1 6 8 4 2 0 3	2764	27	0.019012	11.4317	17
3 5 2 0 8 1 4 6 7	428	19	0.0034724	8.66071	11
8 0 6 7 1 3 5 2 4	715	25	0.00401345	13.0852	21
2 5 8 4 1 0 6 3 7	68	15	0.000280049	7.35246	11
7 0 2 1 8 6 3 4 5	34	17	0.000137684	9.27419	13
2 1 5 3 8 0 6 7 4	121	15	0.000537106	7.37799	7
3 8 6 4 7 0 1 5 2	993	25	0.00581327	10.7449	17
1 0 7 2 4 3 6 8 5	163	17	0.000797134	8.92553	11
3 6 7 5 8 0 4 1 2	2389	27	0.0154612	11.712	17
6 2 0 3 1 4 8 7 5	369	20	0.00187893	8.33812	8
7 1 5 4 0 3 2 6 8	356	20	0.00180117	8.59302	12
8 0 7 4 6 1 5 2 3	1461	27	0.00902094	11.1426	21
8 2 0 5 7 6 1 3 4	854	26	0.00485453	11.4814	18
3 8 5 7 0 1 6 4 2	730	22	0.00404996	9.60016	12
3 5 4 1 7 6 0 2 8	257	22	0.0012856	11.3218	14
0 2 8 5 4 1 7 3 6	414	22	0.00219559	9.85248	12
4 3 7 0 6 1 5 8 2	181	19	0.000875667	9.89644	17
2 1 3 4 6 5 0 7 8	336	20	0.00258222	9.109	8
1 0 5 4 6 2 7 3 8	707	21	0.00446838	8.57759	9
7 2 3 1 5 4 8 6 0	1467	24	0.00899082	11.0388	14
5 7 2 6 4 0 8 3 1	1319	25	0.00793609	10.7828	13

2.4. IDA*

Instância	**Nº Nodos**	**Tamanho Solução**	**Tempo (s)**	**Média h(s)**	**h(s) Inicial**
5 6 2 7 1 8 3 4 0	2631	22	0.00637209	9.77497	12
5 3 2 8 7 1 4 0 6	3276	23	0.00675355	10.5943	15
1 0 7 5 2 4 3 8 6	145	17	0.000476685	9.95062	13
3 6 4 2 8 0 5 7 1	2720	25	0.00609632	11.7755	17
0 6 1 7 4 2 3 8 5	165	16	0.00035832	7.09677	10

0 3 8 2 1 4 7 6 5	1734	22	0.00509215	9.23979	12
0 8 2 1 5 6 7 3 4	1741	22	0.00445623	10.4312	14
5 0 2 6 4 8 1 7 3	439	21	0.00113839	10.7479	11
3 0 8 4 1 2 6 7 5	464	17	0.000949899	7.5844	7
7 2 6 3 1 5 8 0 4	611	21	0.00124491	11.494	13
2 4 7 0 3 6 8 1 5	724	23	0.00148588	11.7103	15
2 1 6 0 4 3 7 5 8	1659	23	0.00342051	10.9092	11
1 2 8 0 3 7 5 6 4	372	19	0.000761423	9.04984	13
1 4 8 2 7 6 0 3 5	1420	22	0.00365507	9.65021	14
5 0 2 1 6 8 7 3 4	465	19	0.00104683	8.18813	13
6 2 1 5 0 4 3 8 7	2130	22	0.00436188	9.6343	10
1 8 0 4 5 2 6 7 3	794	20	0.00165003	9.22578	10
7 6 4 8 1 3 5 0 2	71	21	0.000143585	12.8624	19
1 8 7 5 0 4 2 3 6	456	22	0.000927668	11.5224	18
2 8 0 4 1 7 5 6 3	368	22	0.00101332	10.8775	16
7 8 1 3 6 2 4 5 0	27	16	6.1222e-05	9.42857	14
1 4 7 3 6 2 0 8 5	76	16	0.000158675	8.51639	10
5 2 3 4 7 1 8 0 6	2805	25	0.00576515	11.1237	15
5 1 3 2 6 4 7 8 0	805	22	0.00165864	10.1979	14
1 0 2 5 8 6 4 7 3	1666	23	0.00350605	10.2797	13
4 7 6 0 5 2 3 8 1	2470	25	0.00507286	10.3386	15
5 8 2 1 7 6 3 0 4	1294	21	0.00269938	9.67426	15
3 0 2 6 1 4 5 7 8	100	13	0.000215606	6.92655	7
2 0 1 7 5 3 8 6 4	1609	23	0.00424318	11.2581	13
8 1 0 5 3 7 2 4 6	225	24	0.000464484	13.9746	16
0 2 6 5 4 7 1 3 8	1820	24	0.00507629	11.518	14
4 5 0 1 7 2 3 8 6	129	16	0.000269779	9.44651	12
0 6 3 5 8 2 1 7 4	37	18	0.000100333	10.0508	16
1 4 8 0 7 5 2 6 3	1500	23	0.00306198	10.925	13
1 5 0 8 4 3 2 7 6	4075	26	0.00972105	11.3632	14
2 3 6 8 1 0 5 4 7	5873	27	0.0146496	12.1105	17
1 6 0 7 3 8 4 5 2	487	22	0.0009927	11.7009	14
8 4 3 1 6 5 0 7 2	5296	26	0.0130894	11.0939	14
3 8 2 7 5 1 0 6 4	2349	22	0.00673558	9.76751	12
7 2 3 6 4 8 1 0 5	5296	25	0.0124721	10.856	13
3 1 2 4 0 8 5 7 6	125	14	0.000394232	7.92019	8
8 5 3 1 2 6 4 0 7	3436	25	0.00835546	11.4408	19
2 0 8 6 1 3 4 7 5	1193	21	0.00249335	9.66733	11
3 6 7 1 2 8 4 5 0	9239	26	0.0201471	10.2424	16
0 3 6 1 2 8 4 7 5	2256	24	0.00519117	10.429	14
4 8 6 5 0 7 1 3 2	626	24	0.00127025	13.1367	20
7 2 0 1 8 6 3 4 5	92	18	0.000191686	10.0403	14
4 0 7 1 3 2 5 8 6	1145	23	0.00241075	11.0324	15
1 4 3 0 5 8 7 6 2	1201	21	0.00248484	10.7242	11
1 3 6 5 8 4 0 2 7	5557	28	0.0158091	12.3987	16
3 1 6 4 0 8 7 5 2	730	20	0.00247593	9.96364	12

8 0 5 1 4 3 7 2 6	9355	27	0.0240162	10.6335	15
1 0 2 8 7 3 4 6 5	661	19	0.00138633	8.77668	11
5 8 1 4 7 3 2 6 0	2195	26	0.00533321	12.0853	16
6 4 1 2 0 3 7 8 5	257	18	0.000852426	9.28103	12
6 1 7 4 8 3 5 2 0	2440	24	0.00548292	10.6625	16
0 1 5 3 8 7 6 4 2	339	18	0.000716002	8.48955	8
7 8 2 6 4 3 0 1 5	2316	24	0.00489469	10.8741	12
6 0 8 7 4 3 5 2 1	272	23	0.000576957	13.1748	17
5 4 0 7 6 2 8 3 1	3401	24	0.00769512	10.8254	16
5 6 1 8 7 0 2 4 3	9544	27	0.0226991	11.4995	19
1 6 7 4 2 0 3 5 8	8845	25	0.0201859	9.66801	13
5 3 6 4 7 2 1 0 8	360	21	0.000837705	10.3406	15
0 8 7 4 2 6 1 3 5	103	22	0.000234117	13.3125	18
7 2 0 5 4 3 8 6 1	11359	28	0.0251268	11.5501	14
5 3 0 6 7 1 8 2 4	406	20	0.000867697	9.65875	16
5 7 2 8 3 6 4 0 1	8302	27	0.0177628	11.2233	17
3 7 8 1 4 6 5 0 2	6762	27	0.0144483	11.8568	15
7 4 5 8 6 3 2 0 1	2421	25	0.00697082	11.3534	19
0 4 1 8 2 5 3 7 6	3944	24	0.00978645	9.62323	10
5 1 7 2 3 6 8 4 0	899	24	0.00189385	11.5017	16
6 3 4 8 2 1 5 7 0	868	22	0.00190784	10.4893	16
2 0 1 5 7 6 4 8 3	14476	27	0.0316828	10.9017	15
7 8 0 6 3 1 2 5 4	3141	26	0.0069535	11.7179	18
6 2 4 3 7 0 5 1 8	8979	25	0.0198654	9.91441	11
7 5 4 8 3 6 0 2 1	1631	26	0.00340887	11.5896	20
3 8 4 5 7 1 0 6 2	413	20	0.000878187	9.48012	14
5 6 2 8 7 1 0 3 4	8936	26	0.0198884	10.4408	16
3 2 4 6 5 8 0 7 1	166	16	0.000359391	8.79371	10
7 5 1 6 8 4 2 0 3	7986	27	0.0198797	11.3515	17
3 5 2 0 8 1 4 6 7	490	19	0.0010617	8.27494	11
8 0 6 7 1 3 5 2 4	324	25	0.000667361	14.1297	21
2 5 8 4 1 0 6 3 7	56	15	0.000122744	7.91011	11
7 0 2 1 8 6 3 4 5	83	17	0.000207026	9.68148	13
2 1 5 3 8 0 6 7 4	186	15	0.000428653	7.26198	7
3 8 6 4 7 0 1 5 2	2713	25	0.0130098	11.4693	17
1 0 7 2 4 3 6 8 5	206	17	0.000452904	9.24069	11
3 6 7 5 8 0 4 1 2	5691	27	0.0214881	11.7926	17
6 2 0 3 1 4 8 7 5	1408	20	0.00312801	8.11884	8
7 1 5 4 0 3 2 6 8	573	20	0.00123788	9.41962	12
8 0 7 4 6 1 5 2 3	2764	27	0.00595614	11.3216	21
8 2 0 5 7 6 1 3 4	2791	26	0.00596819	10.9685	18
3 8 5 7 0 1 6 4 2	2006	22	0.0066855	9.71186	12
3 5 4 1 7 6 0 2 8	1238	22	0.0027112	10.9558	14
0 2 8 5 4 1 7 3 6	1016	22	0.0129573	10.9727	12
4 3 7 0 6 1 5 8 2	244	19	0.000510636	9.90074	17
2 1 3 4 6 5 0 7 8	722	20	0.00156857	9.40443	8
1 0 5 4 6 2 7 3 8	2213	21	0.00515439	8.08958	9
7 2 3 1 5 4 8 6 0	2265	24	0.00486057	11.2732	14
5 7 2 6 4 0 8 3 1	3613	25	0.00780032	10.6734	13

2.5. GBFS

Instância	Nº Nodos	Tamanho Solução	Tempo (s)	Média h(s)	h(s) Inicial
5 6 2 7 1 8 3 4 0	579	156	0.00589958	7.00877	12
5 3 2 8 7 1 4 0 6	437	187	0.00519691	6.86951	15
1 0 7 5 2 4 3 8 6	430	189	0.00343141	6.61075	13
3 6 4 2 8 0 5 7 1	466	207	0.00383447	6.94545	17
0 6 1 7 4 2 3 8 5	16	16	4.6812e-05	5.5	10
0 3 8 2 1 4 7 6 5	407	152	0.00279852	6.59085	12
0 8 2 1 5 6 7 3 4	422	168	0.00316683	6.6126	14
5 0 2 6 4 8 1 7 3	96	27	0.00032362	8.05422	11
3 0 8 4 1 2 6 7 5	576	87	0.00440555	6.73002	7
7 2 6 3 1 5 8 0 4	634	119	0.00725933	7.05254	13
2 4 7 0 3 6 8 1 5	90	57	0.00033663	6.80982	15
2 1 6 0 4 3 7 5 8	560	141	0.0044515	6.93239	11
1 2 8 0 3 7 5 6 4	83	47	0.000283859	5.89116	13
1 4 8 2 7 6 0 3 5	502	146	0.00412609	6.7343	14
5 0 2 1 6 8 7 3 4	66	39	0.000331001	6.13445	13
6 2 1 5 0 4 3 8 7	501	146	0.00518726	6.69877	10
1 8 0 4 5 2 6 7 3	81	44	0.000258618	6.51064	10
7 6 4 8 1 3 5 0 2	46	37	0.000142934	7.86905	19
1 8 7 5 0 4 2 3 6	386	160	0.00306878	6.8064	18
2 8 0 4 1 7 5 6 3	429	190	0.00434253	6.8082	16
7 8 1 3 6 2 4 5 0	540	132	0.00435108	6.77443	14
1 4 7 3 6 2 0 8 5	453	166	0.00325203	6.64375	10
5 2 3 4 7 1 8 0 6	464	181	0.00348643	6.87607	15
5 1 3 2 6 4 7 8 0	651	198	0.00601635	7.22193	14
1 0 2 5 8 6 4 7 3	406	189	0.00343456	6.62845	13
4 7 6 0 5 2 3 8 1	423	187	0.00344824	6.83737	15
5 8 2 1 7 6 3 0 4	453	203	0.00395015	6.81716	15
3 0 2 6 1 4 5 7 8	17	15	5.4411e-05	5.38235	7
2 0 1 7 5 3 8 6 4	405	165	0.00455598	6.69777	13
8 1 0 5 3 7 2 4 6	542	140	0.00461344	6.95327	16
0 2 6 5 4 7 1 3 8	135	38	0.000485505	8.6913	14
4 5 0 1 7 2 3 8 6	67	34	0.000208957	7.91453	12
0 6 3 5 8 2 1 7 4	452	194	0.00394919	6.75905	16
1 4 8 0 7 5 2 6 3	432	195	0.00422056	6.80921	13
1 5 0 8 4 3 2 7 6	521	162	0.00463275	6.9145	14
2 3 6 8 1 0 5 4 7	111	79	0.000440034	7.82741	17
1 6 0 7 3 8 4 5 2	590	98	0.00480747	6.83349	14
8 4 3 1 6 5 0 7 2	549	148	0.00510726	6.89877	14
3 8 2 7 5 1 0 6 4	447	184	0.00372585	6.72819	12
7 2 3 6 4 8 1 0 5	460	211	0.00588938	6.95679	13
3 1 2 4 0 8 5 7 6	394	140	0.00257769	6.4721	8

8 5 3 1 2 6 4 0 7	65	45	0.000219146	7.79832	19
2 0 8 6 1 3 4 7 5	510	155	0.00455056	6.72898	11
3 6 7 1 2 8 4 5 0	525	222	0.00456525	6.77065	16
0 3 6 1 2 8 4 7 5	533	130	0.00610925	6.88877	14
4 8 6 5 0 7 1 3 2	416	184	0.0033937	6.96346	20
7 2 0 1 8 6 3 4 5	19	18	7.9943e-05	7.47222	14
4 0 7 1 3 2 5 8 6	428	181	0.00369373	6.7876	15
1 4 3 0 5 8 7 6 2	552	149	0.00477353	6.85234	11
1 3 6 5 8 4 0 2 7	461	198	0.00381339	7.30037	16
3 1 6 4 0 8 7 5 2	496	174	0.00353299	7.07913	12
8 0 5 1 4 3 7 2 6	88	49	0.000304379	7.53896	15
1 0 2 8 7 3 4 6 5	601	101	0.00650549	6.78992	11
5 8 1 4 7 3 2 6 0	452	206	0.00382938	7.27904	16
6 4 1 2 0 3 7 8 5	560	132	0.00459578	6.86391	12
6 1 7 4 8 3 5 2 0	43	36	0.000138845	7.33333	16
0 1 5 3 8 7 6 4 2	480	180	0.00520158	6.94675	8
7 8 2 6 4 3 0 1 5	459	216	0.00453719	7.02829	12
6 0 8 7 4 3 5 2 1	80	55	0.000358991	7.75887	17
5 4 0 7 6 2 8 3 1	68	46	0.000232037	6.6281	16
5 6 1 8 7 0 2 4 3	525	219	0.0044703	6.79652	19
1 6 7 4 2 0 3 5 8	401	153	0.00280632	6.59748	13
5 3 6 4 7 2 1 0 8	632	195	0.0059982	7.22292	15
0 8 7 4 2 6 1 3 5	416	188	0.00330883	6.95522	18
7 2 0 5 4 3 8 6 1	496	210	0.00428889	7.47886	14
5 3 0 6 7 1 8 2 4	20	20	5.7241e-05	7.91667	16
5 7 2 8 3 6 4 0 1	659	129	0.00608256	7.1188	17
3 7 8 1 4 6 5 0 2	474	197	0.00378736	6.95585	15
7 4 5 8 6 3 2 0 1	62	41	0.000221706	7.63393	19
0 4 1 8 2 5 3 7 6	423	170	0.00327868	6.56225	10
5 1 7 2 3 6 8 4 0	514	158	0.00447454	6.83297	16
6 3 4 8 2 1 5 7 0	394	166	0.00445984	6.625	16
2 0 1 5 7 6 4 8 3	420	181	0.00357014	6.91263	15
7 8 0 6 3 1 2 5 4	410	178	0.00324513	6.70621	18
6 2 4 3 7 0 5 1 8	386	175	0.00308208	6.51458	11
7 5 4 8 3 6 0 2 1	448	176	0.00350023	6.87753	20
3 8 4 5 7 1 0 6 2	389	164	0.00288318	6.53546	14
5 6 2 8 7 1 0 3 4	466	194	0.00537475	6.90413	16
3 2 4 6 5 8 0 7 1	453	194	0.00541898	6.61615	10
7 5 1 6 8 4 2 0 3	442	193	0.00530887	6.83655	17
3 5 2 0 8 1 4 6 7	590	129	0.00435212	6.82882	11
8 0 6 7 1 3 5 2 4	454	197	0.00369835	7.0087	21
2 5 8 4 1 0 6 3 7	57	39	0.000210956	5.57547	11
7 0 2 1 8 6 3 4 5	18	17	5.5461e-05	7.25714	13
2 1 5 3 8 0 6 7 4	387	149	0.00257676	6.43586	7
3 8 6 4 7 0 1 5 2	572	175	0.00508995	7.08036	17

1 0 7 2 4 3 6 8 5	417	179	0.00497779	6.6449	11
3 6 7 5 8 0 4 1 2	596	175	0.00559509	7.10293	17
6 2 0 3 1 4 8 7 5	382	168	0.00292141	6.38881	8
7 1 5 4 0 3 2 6 8	522	150	0.00442148	6.74273	12
8 0 7 4 6 1 5 2 3	580	151	0.00682178	7.11359	21
8 2 0 5 7 6 1 3 4	458	208	0.00398607	6.90999	18
3 8 5 7 0 1 6 4 2	485	176	0.00422069	6.98945	12
3 5 4 1 7 6 0 2 8	580	152	0.00596716	6.98928	14
0 2 8 5 4 1 7 3 6	409	152	0.00350112	6.71724	12
4 3 7 0 6 1 5 8 2	403	161	0.00459328	6.64895	17
2 1 3 4 6 5 0 7 8	636	186	0.00569034	7.13375	8
1 0 5 4 6 2 7 3 8	48	29	0.000227077	5.71591	9
7 2 3 1 5 4 8 6 0	613	104	0.0060164	6.96051	14
5 7 2 6 4 0 8 3 1	450	203	0.00387895	6.84375	13

2.6. A* no 15-puzzle

Instância	Nº Nodos	Tamanho Solução	Tempo (s)	Média h(s)	h(s) Inicial
14 13 15 7 11 12 9 5 6 0 2 1 4 8 10 3	14028344	57	171.632	27.1869	41
13 5 4 10 9 12 8 14 2 3 7 1 0 15 11 6	4415279	55	47.6099	23.3948	43
14 7 8 2 13 11 10 4 9 12 5 0 3 6 1 15	30003145	59	388.154	27.7517	41
5 12 10 7 15 11 14 0 8 2 1 13 3 4 9 6	5253685	56	58.1793	26.6208	42
4 7 14 13 10 3 9 12 11 5 6 15 1 2 8 0	2021382	56	20.3756	28.1532	42
14 7 1 9 12 3 6 15 8 11 2 5 10 0 4 13	969356	52	9.16081	27.4165	36
2 11 15 5 13 4 6 7 12 8 10 1 9 3 14 0	7170013	52	84.3681	23.3837	30

12 11 15 3 8 0 4 2 6 13 9 5 14 1 10 7	2618503	50	27.4541	24.4245	32
3 14 9 11 5 4 8 2 13 12 6 7 10 1 15 0	313211	46	2.83133	21.5037	32
13 11 8 9 0 15 7 10 4 3 6 14 5 12 2 1	17805045	59	223.414	27.735	43
5 9 13 14 6 3 7 12 10 8 4 0 15 2 11 1	3525006	57	38.0766	28.7505	43
14 1 9 6 4 8 12 5 7 2 3 0 10 11 13 15	32334	45	0.206831	26.2362	35
3 6 5 2 10 0 15 14 1 4 13 12 9 8 11 7	831333	46	7.99114	19.5075	36
7 6 8 1 11 5 14 10 3 4 9 13 15 2 0 12	26088053	59	347.167	28.499	41
13 11 4 12 1 8 9 15 6 5 14 2 7 3 10 0	25792756	62	316.594	31.4546	44
1 3 2 5 10 9 15 6 8 14 13 11 12 4 7 0	909219	42	8.27634	18.6516	24
15 14 0 4 11 1 6 13 7 5 8 9 3 2 10 12	-	-	-	-	-
6 0 14 12 1 15 9 10 11 4 7 2 8 3 5 13	1267588	55	10.8208	27.2594	43

7 11 8 3 14 0 6 15 1 4 13 9 5 12 2 10	154092	46	1.08644	22.9871	36
6 12 11 3 13 7 9 15 2 14 8 10 4 1 5 0	1995813	52	18.2856	24.573	36
12 8 14 6 11 4 7 0 5 1 10 15 3 13 9 2	5668025	54	59.1185	26.4034	34
14 3 9 1 15 8 4 5 11 7 10 13 0 2 12 6	13338796	59	147.636	28.2474	41
10 9 3 11 0 13 2 14 5 6 4 7 8 15 1 12	1398857	49	12.8874	24.2771	33
7 3 14 13 4 1 10 8 5 12 9 11 2 15 6 0	4691710	54	47.7488	26.3122	34
11 4 2 7 1 0 10 15 6 9 14 8 3 13 5 12	6227205	52	65.2512	24.7003	32
5 7 3 12 15 13 14 8 0 10 9 6 1 4 2 11	20161235	58	230.115	27.5853	40
14 1 8 15 2 6 0 3 9 12 10 13 4 7 5 11	11278428	53	126.059	25.4592	33
13 14 6 12 4 5 1 0 9 3 10 2 15 11 8 7	909442	52	7.86724	27.8727	36
9 8 0 2 15 1 4 14 3 10 7 5 11 13 6 12	3917549	54	38.7979	26.1191	38
12 15 2 6 1 14 4 8 5 3 7 0 10 13 9 11	215990	47	1.58512	24.8402	35

12 8 15 13 1 0 5 4 6 3 2 11 9 7 14 10	192534	50	1.3877	28.1648	38
14 10 9 4 13 6 5 8 2 12 7 0 1 3 11 15	17025056	59	187.592	29.2737	43
14 3 5 15 11 6 13 9 0 10 2 12 4 1 7 8	18535767	60	208.377	30.1101	42
6 11 7 8 13 2 5 4 1 10 3 9 14 0 12 15	2063117	52	19.3597	25.9825	36
1 6 12 14 3 2 15 8 4 5 13 9 0 7 11 10	4626661	55	45.1023	26.9748	39
12 6 0 4 7 3 15 1 13 9 8 11 2 14 5 10	2309697	52	21.8745	25.7915	36
8 1 7 12 11 0 10 5 9 15 6 13 14 2 3 4	20889986	58	241.472	27.636	40
7 15 8 2 13 6 3 12 11 0 4 10 9 5 1 14	827864	53	7.00137	28.7101	41
9 0 4 10 1 14 15 3 12 6 5 7 11 13 8 2	1118025	49	10.0579	24.2808	35
11 5 1 14 4 12 10 0 2 7 13 3 9 15 6 8	6540243	54	69.3049	26.3806	36
8 13 10 9 11 3 15 6 0 1 2 14 12 5 4 7	5727374	54	59.2326	26.1219	36
4 5 7 2 9 14 12 13 0 3 6 11 8 1 15 10	48447	42	0.299064	23.3	30

11 15 14 13 1 9 10 4 3 6 2 12 7 5 8 0	7332466	64	74.3874	33.0528	48
12 9 0 6 8 3 5 14 2 4 11 7 10 1 15 13	2731989	50	26.1631	24.6075	32
3 14 9 7 12 15 0 4 1 8 5 6 11 10 2 13	539196	51	4.26229	27.3161	39
8 4 6 1 14 12 2 15 13 10 9 5 3 7 0 11	1430455	49	12.8169	22.9179	35
6 10 1 14 15 8 3 5 13 0 2 7 4 9 11 12	179689	47	1.30707	25.4753	35
8 11 4 6 7 3 10 9 2 12 15 13 0 1 5 14	119535	49	0.801353	25.1685	39
10 0 2 4 5 1 6 12 11 13 9 7 15 3 14 8	-	-	-	-	-
12 5 13 11 2 10 0 9 7 8 4 3 14 6 15 1	4399444	53	44.8877	25.0994	39
10 2 8 4 15 0 1 14 11 13 3 6 9 7 5 12	3031922	56	28.9874	28.0748	44
10 8 0 12 3 7 6 2 1 14 4 11 15 13 9 5	11641228	56	131.095	26.8034	38
14 9 12 13 15 4 8 10 0 2 1 7 3 11 5 6	38607523	64	459.306	30.4284	50
12 11 0 8 10 2 13 15 5 4 7 3 6 9 14 1	7221615	56	77.4298	27.8207	40

13 8 14 3 9 1 0 7 15 5 4 10 12 2 6 11	152123	41	1.07866	20.6961	29
3 15 2 5 11 6 4 7 12 9 1 0 13 14 10 8	46798812	55	646.546	25.3307	29
5 11 6 9 4 13 12 0 8 2 15 10 1 7 3 14	484048	50	3.88263	26.1174	36
5 0 15 8 4 6 1 14 10 11 3 9 7 12 2 13	506538	51	4.25275	25.5453	37
15 14 6 7 10 1 0 11 12 8 4 9 2 5 13 3	49797791	57	749.402	26.7052	35
11 14 13 1 2 3 12 4 15 7 9 5 10 6 8 0	-	-	-	-	-
6 13 3 2 11 9 5 10 1 7 12 14 8 4 0 15	508957	45	4.49946	21.7271	31
4 6 12 0 14 2 9 13 11 8 3 15 7 10 1 5	1828847	57	16.7594	29.0846	43
8 10 9 11 14 1 7 15 13 4 0 12 6 2 5 3	21862510	56	283.027	25.5476	40
5 2 14 0 7 8 6 3 11 12 13 15 4 10 9 1	5622335	51	63.7958	23.6183	31
7 8 3 2 10 12 4 6 11 13 5 15 0 1 9 14	920623	47	8.93232	22.6228	31
11 6 14 12 3 5 1 15 8 0 10 13 9 7 4 2	-	-	-	-	-

7 1 2 4 8 3 6 11 10 15 0 5 14 12 13 9	8430894	50	89.7403	23.9214	28
7 3 1 13 12 10 5 2 8 0 6 11 14 15 4 9	5471060	51	59.0188	25.118	31
6 0 5 15 1 14 4 9 2 13 8 10 11 12 7 3	4579005	53	48.1734	25.3428	37
15 1 3 12 4 0 6 5 2 8 14 9 13 10 7 11	8179227	52	90.84	24.6644	30
5 7 0 11 12 1 9 10 15 6 2 3 8 4 13 14	557862	44	4.77505	20.6301	30
12 15 11 10 4 5 14 0 13 7 1 2 9 8 3 6	34437004	56	427.134	25.3943	38
6 14 10 5 15 8 7 1 3 4 2 0 12 9 11 13	188717	49	1.42706	23.8731	37
14 13 4 11 15 8 6 9 0 7 3 1 2 10 12 5	1373939	56	13.023	28.7716	46
14 4 0 10 6 5 1 3 9 2 13 15 12 7 8 11	3440513	48	35.3453	22.0602	30
15 10 8 3 0 6 9 5 1 14 13 11 7 2 12 4	7622602	57	83.2198	27.7297	41
0 13 2 4 12 14 6 9 15 1 10 3 11 5 8 7	2184110	54	21.5668	27.598	34
3 14 13 6 4 15 8 9 5 12 10 0 2 7 1 11	619299	53	4.99184	27.3807	41

0 1 9 7 11 13 5 3 14 12 4 2 8 6 10 15	68633	42	0.443965	21.7811	28
11 0 15 8 13 12 3 5 10 1 4 6 14 9 7 2	3951356	57	39.9689	26.9136	43
13 0 9 12 11 6 3 5 15 8 1 10 4 14 2 7	744209	53	6.59459	28.0517	39
14 10 2 1 13 9 8 11 7 3 6 12 15 5 4 0	-	-	-	-	-
12 3 9 1 4 5 10 2 6 11 15 0 14 7 13 8	1900358	49	18.1302	24.1278	31
15 8 10 7 0 12 14 1 5 9 6 3 13 11 4 2	10972804	55	125.424	26.659	37
4 7 13 10 1 2 9 6 12 8 14 5 3 0 11 15	158355	44	1.29216	20.8886	32
6 0 5 10 11 12 9 2 1 7 4 3 14 8 13 15	195222	45	1.65606	22.2905	35
9 5 11 10 13 0 2 1 8 6 14 12 4 7 3 15	4681483	52	52.9838	25.962	34
15 2 12 11 14 13 9 5 1 3 8 7 0 10 6 4	-	-	-	-	-
11 1 7 4 10 13 3 8 9 14 0 15 6 5 2 12	3559259	54	36.3883	26.4619,38	
5 4 7 1 11 12 14 15 10 13 8 6 2 0 9 3	820923	50	7.091	26.0792,36	

9 7 5 2 14 15 12 10 11 3 6 1 8 13 0 4	18150875	57	211.85	26.8734,41
3 2 7 9 0 15 12 4 6 11 5 14 8 13 10 1	45112197	57	588.427	25.8101,37
13 9 14 6 12 8 1 2 3 4 0 7 5 10 11 15	438960	46	3.72125	20.9652,34
5 7 11 8 0 14 9 13 10 12 3 15 6 1 4 2	276325	53	2.22663	27.7666,45
4 3 6 13 7 15 9 0 10 5 8 11 2 12 1 14	751475	50	6.83548	25.0634,34
1 7 15 14 2 6 4 9 12 11 13 3 0 8 5 10	1263033	49	11.9227	22.9222,35
9 14 5 7 8 15 1 2 10 4 13 6 12 0 11 3	191601	44	1.48478	21.2678,32
0 11 3 12 5 2 1 9 8 10 14 15 7 4 13 6	9499694	54	106.549	25.1273,34
7 15 4 0 10 9 2 5 12 11 13 6 1 3 14 8	5342754	57	55.388	28.7625,39
11 4 0 8 6 10 5 13 12 7 14 3 1 2 9 15	4484857	54	45.7848	25.1702,38