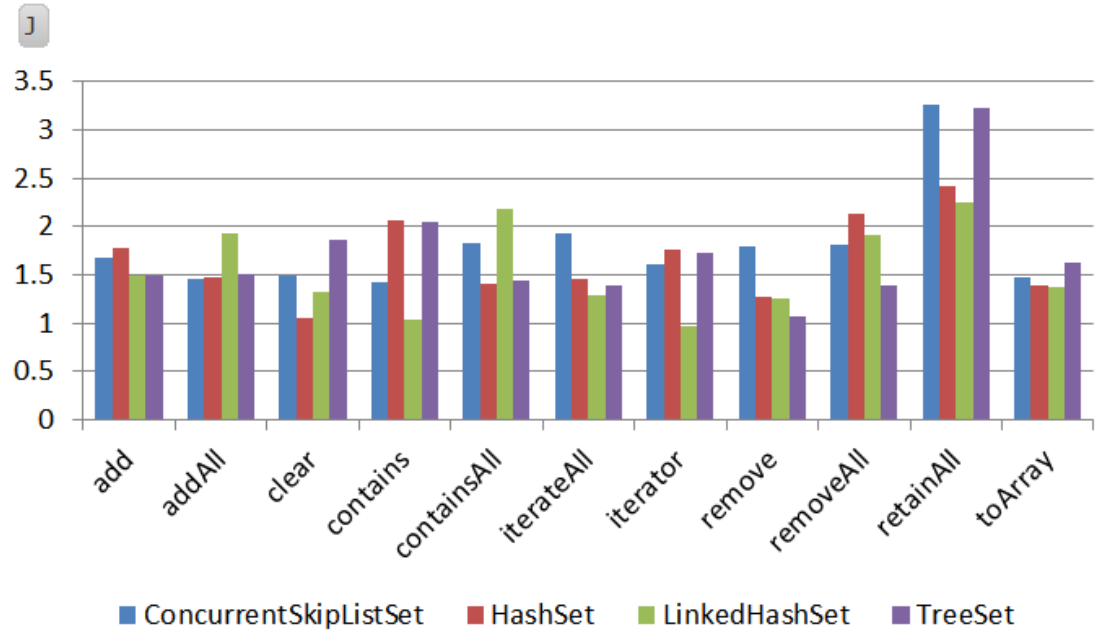
APPENDIX

Pereira, Couto, Cunha, Fernandes, and Saraiva

Appendices

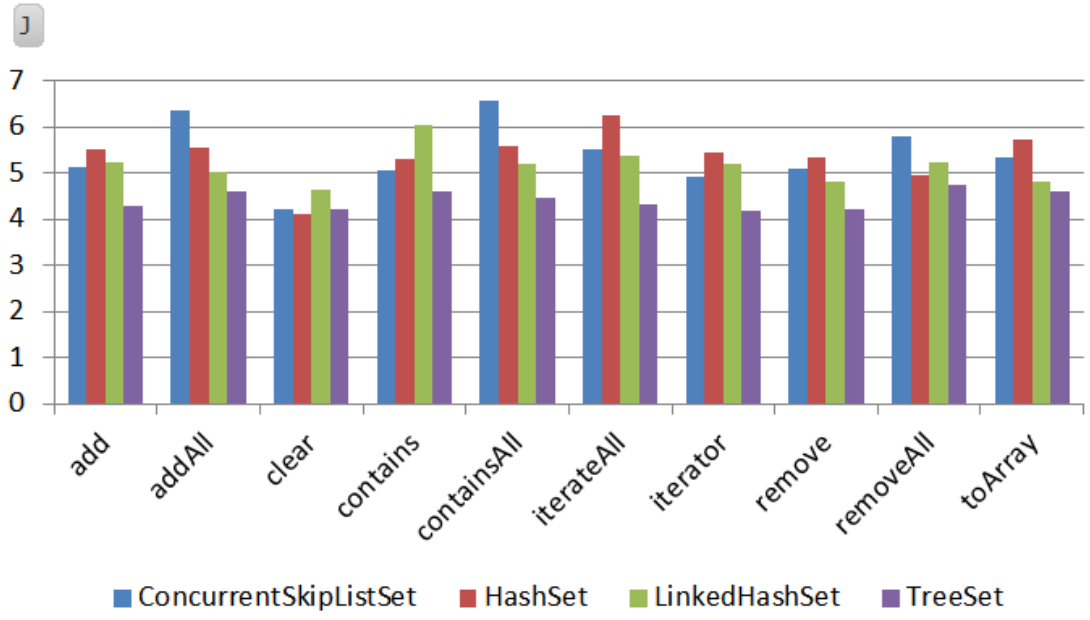
A Set data for 25k population

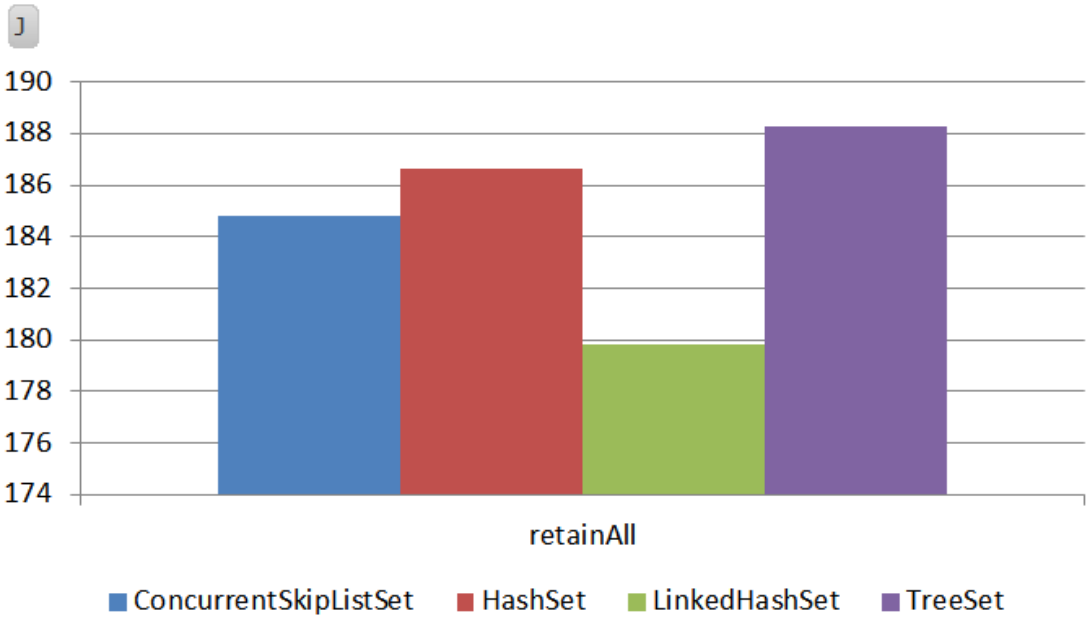
Methods	Concurrent SkipListSet J	ms	HashSet J	ms	Linked HashSet J	ms	TreeSet J	ms
add	1.6822	87	1.7749	87	1.4917	75	1.4817	92
addAll	1.4549	93	1.4771	89	1.9335	94	1.5101	93
clear	1.4901	78	1.0586	64	1.3288	60	1.8566	73
contains	1.4213	88	2.0685	78	1.0401	76	2.0446	79
containsAll	1.8317	96	1.4000	77	2.1748	88	1.4443	89
iterateAll	1.9225	99	1.4554	92	1.2907	83	1.3844	83
iterator	1.6096	83	1.7596	75	0.9613	76	1.7239	76
remove	1.7877	78	1.2633	75	1.2458	93	1.0700	76
removeAll	1.8072	85	2.1359	77	1.9145	100	1.3920	91
retainAll	3.2607	206	2.4092	200	2.2512	199	3.2222	193
toArray	1.4789	86	1.3833	80	1.3776	79	1.6292	80



B Set data for 250k population

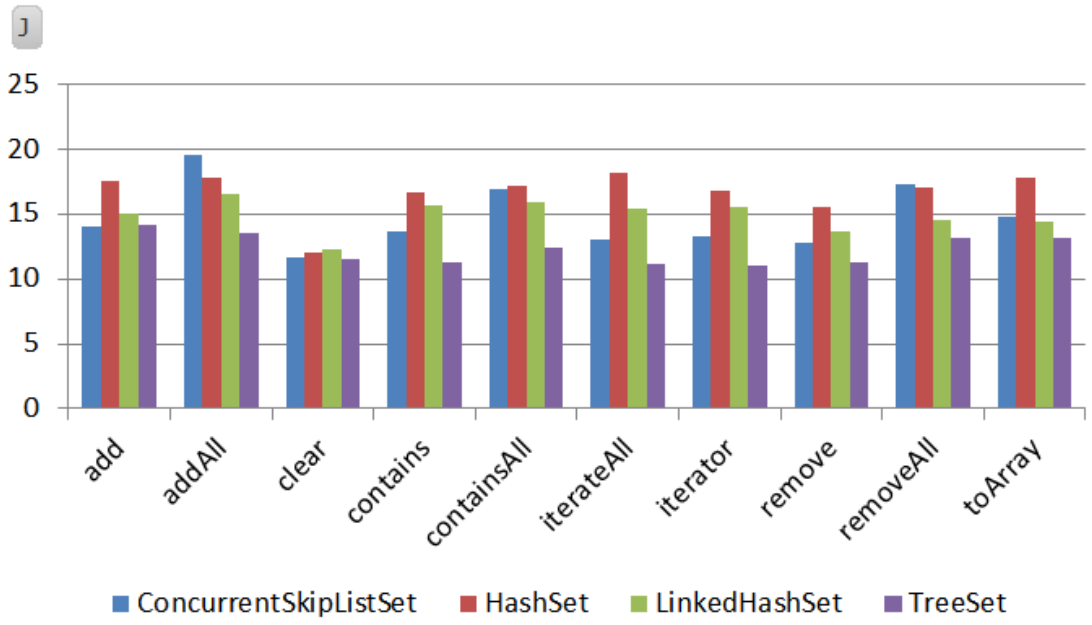
Methods	Concurrent SkipListSet J	ms	HashSet J	ms	Linked HashSet J	ms	TreeSet J	ms
add	5.1254	284	5.5141	305	5.2348	277	4.2959	233
addAll	6.3474	391	5.5436	307	5.0125	279	4.5978	288
clear	4.2285	246	4.1085	227	4.6213	241	4.2033	229
contains	5.0685	272	5.2959	290	6.0423	251	4.5884	216
containsAll	6.5672	351	5.5917	291	5.1875	259	4.4657	254
iterateAll	5.4969	266	6.2567	298	5.3597	270	4.3067	247
iterator	4.9175	249	5.4548	290	5.1849	265	4.1703	214
remove	5.0868	260	5.3462	270	4.8186	255	4.2111	225
removeAll	5.7957	364	4.9622	295	5.2345	260	4.7445	278
retainAll	184.7828	17079	186.6178	17367	179.7946	16563	188.2510	17516
toArray	5.3265	270	5.7374	305	4.7959	271	4.5845	245

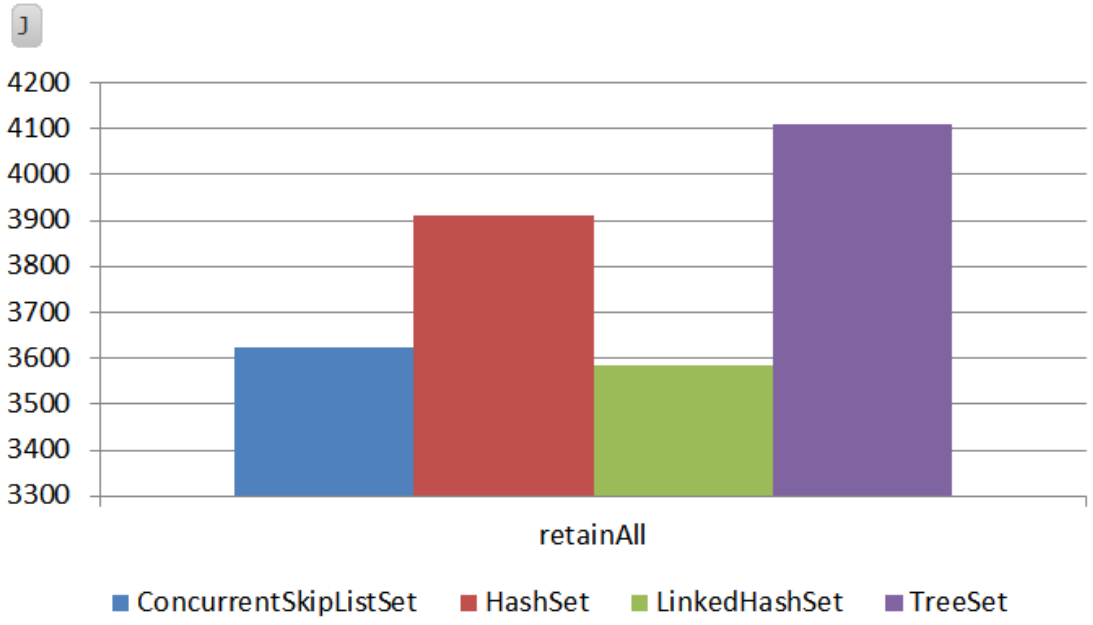



J
190
188
186
184
182
180
178
176
174
retainAll
ConcurrentSkipListSet
HashSet
LinkedHashSet
TreeSet

C Set data for 1m population

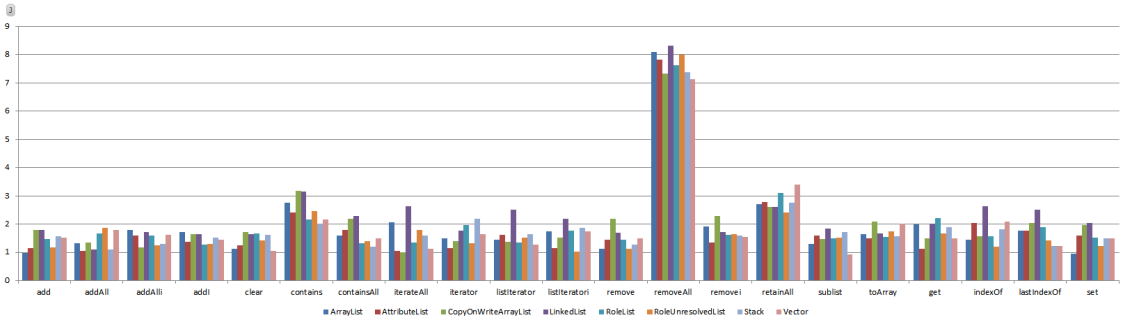
Methods	Concurrent SkipListSet J	ms	HashSet J	ms	Linked HashSet J	ms	TreeSet J	ms
add	14.0472	824	17.5243	1072	15.0643	876	14.1021	758
addAll	19.5092	1518	17.8589	1100	16.5155	983	13.5737	983
clear	11.5958	747	12.0199	764	12.2874	770	11.5565	758
contains	13.6576	870	16.6950	1014	15.6210	880	11.2337	682
containsAll	16.9809	1212	17.2110	1038	15.8865	886	12.3979	844
iterateAll	13.0184	785	18.1706	1091	15.4155	865	11.2088	684
iterator	13.2534	752	16.7433	1013	15.5284	850	11.0499	641
remove	12.7444	789	15.5699	949	13.6615	799	11.2653	675
removeAll	17.2849	1293	17.0514	998	14.5821	841	13.2071	937
retainAll	3621.9872	346898	3912.0129	384829	3584.3529	346337	4111.2397	408297
toArray	14.8120	875	17.8458	1070	14.3511	848	13.1271	750




J
4200
4100
4000
3900
3800
3700
3600
3500
3400
3300
retainAll
ConcurrentSkipListSet
HashSet
LinkedHashSet
TreeSet

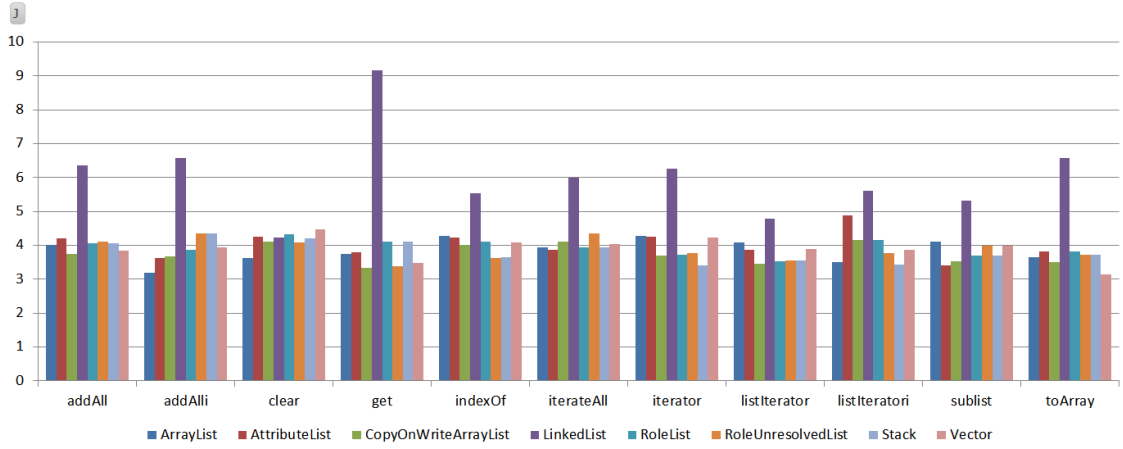
D List data for 25k population

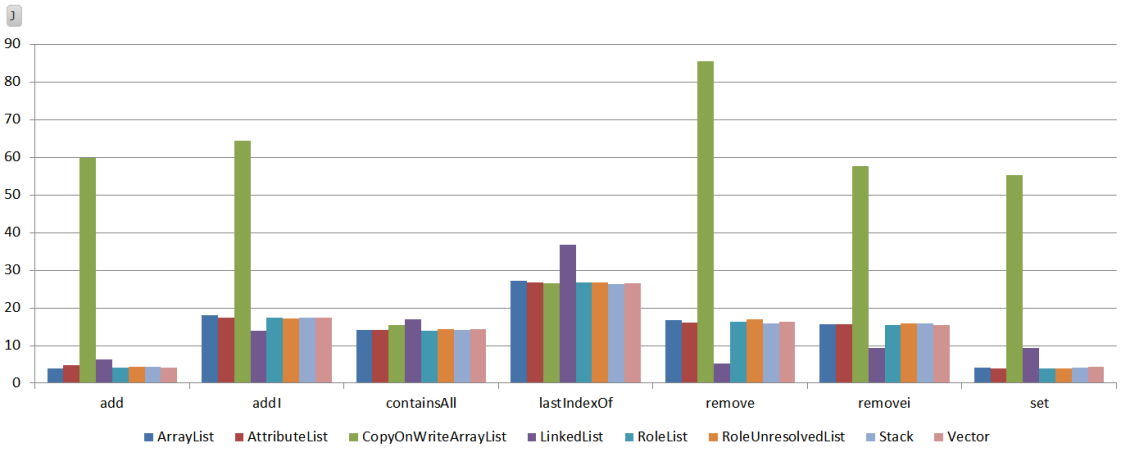
	ArrayList		AttributeList		CopyOn Write ArrayList		LinkedList		RoleList		Role Unresolved List		Stack		Vector	
Methods	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms
add	0.9773	71	1.1510	67	1.7839	117	1.8016	86	1.4801	76	1.1865	74	1.5659	76	1.5177	69
addAll	1.3353	76	1.0492	88	1.3586	82	1.1043	88	1.6661	76	1.8672	88	1.1015	88	1.7903	73
addAlli	1.7855	86	1.6035	68	1.1789	86	1.7272	99	1.5980	81	1.2497	85	1.2962	72	1.6268	90
addI	1.7125	93	1.3849	87	1.6558	119	1.6404	96	1.2718	85	1.3124	86	1.5287	83	1.4554	86
clear	1.1284	76	1.2409	75	1.7155	68	1.6497	74	1.6705	76	1.4304	80	1.6199	73	1.0574	71
contains	2.7568	166	2.4228	165	3.1768	167	3.1552	193	2.1751	162	2.4688	164	2.0128	166	2.1558	168
containsAll	1.5993	87	1.8053	92	2.1889	92	2.2887	118	1.3244	100	1.3930	96	1.2054	89	1.5091	87
get	2.0029	83	1.1171	78	1.4918	77	2.0168	109	2.2110	81	1.6613	71	1.8956	86	1.4978	73
indexOf	1.4447	76	2.0325	84	1.5682	70	2.6289	101	1.5674	79	1.1944	81	1.8090	81	2.0788	75
iterateAll	2.0701	79	1.0473	77	1.0103	73	2.6401	107	1.3605	85	1.7822	71	1.6036	81	1.1336	87
iterator	1.4893	84	1.1589	84	1.3922	72	1.7666	108	1.9760	73	1.3300	79	2.1895	84	1.6505	83
lastIndexOf	1.7750	99	1.7666	98	2.0383	94	2.5019	127	1.8914	92	1.4211	95	1.2260	84	1.2296	96
listIterator	1.4457	76	1.6190	84	1.3737	71	2.5003	106	1.3380	80	1.5176	85	1.6354	69	1.2746	81
listIteratori	1.7356	78	1.1552	81	1.5160	77	2.1996	105	1.7588	79	1.0334	80	1.8799	85	1.7545	78
remove	1.1308	96	1.4480	85	2.1946	162	1.6924	98	1.4560	84	1.1368	85	1.2663	96	1.4973	82
removeAll	8.0905	671	7.8108	697	7.3237	666	8.3150	752	7.6148	692	7.9911	664	7.3824	654	7.1281	665
removei	1.9135	85	1.3534	92	2.2858	118	1.7174	100	1.6308	85	1.6369	89	1.5850	81	1.5486	90
retainAll	2.7037	193	2.7845	200	2.6052	198	2.5982	205	3.0973	197	2.4172	200	2.7635	242	3.4019	245
set	0.9476	64	1.5943	70	1.9669	110	2.0474	112	1.5249	76	1.2312	73	1.4938	75	1.4957	72
sublist	1.3108	76	1.6021	80	1.4792	80	1.8457	98	1.4910	85	1.5117	71	1.7082	75	0.9414	75
toArray	1.6418	84	1.5024	84	2.0934	73	1.6739	106	1.5418	79	1.7455	83	1.5694	69	2.0213	80

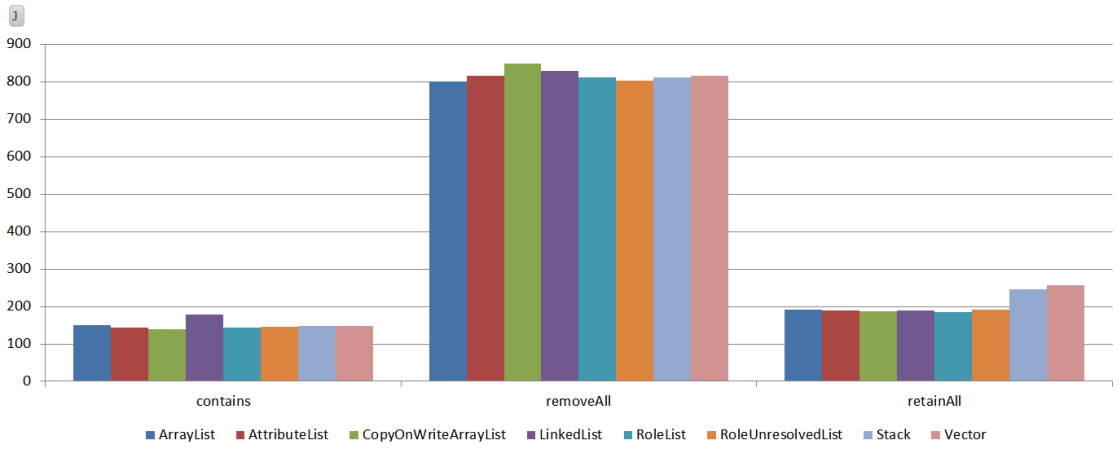


E List data for 250k population

	ArrayList		AttributeList		CopyOn Write ArrayList		LinkedList		RoleList		Role Unresolved List		Stack		Vector	
Methods	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms
add	3.8352	225	4.6749	228	59.9706	5552	6.2024	294	4.0685	223	4.3435	222	4.3659	225	4.0186	221
addAll	4.0158	213	4.1970	213	3.7459	212	6.3524	306	4.0595	236	4.1118	233	4.0586	211	3.8572	217
addAlli	3.1822	200	3.6327	196	3.6868	195	6.5870	318	3.8740	221	4.3522	198	4.3606	222	3.9313	229
addI	17.9630	1366	17.5091	1372	64.4550	6091	13.8804	1037	17.3695	1371	17.1374	1366	17.4695	1365	17.4099	1368
clear	3.6320	218	4.2446	238	4.1154	219	4.2423	225	4.3240	221	4.0848	237	4.1995	220	4.4717	238
contains	149.2101	14930	143.8105	14297	138.7096	13608	177.4864	17145	143.5583	14361	144.8360	14440	148.3477	14941	147.6217	14919
containsAll	14.2118	1210	14.1992	1161	15.4383	1282	16.9662	1399	13.9955	1178	14.3545	1184	14.0874	1155	14.2835	1160
get	3.7491	225	3.8010	196	3.3272	196	9.1736	738	4.1234	194	3.3873	203	4.1009	200	3.4824	195
indexOf	4.2838	207	4.2417	208	4.0170	213	5.5329	275	4.1047	230	3.6321	201	3.6502	202	4.0763	204
iterateAll	3.9417	205	3.8646	206	4.1047	200	6.0103	303	3.9434	229	4.3596	209	3.9510	224	4.0285	232
iterator	4.2709	196	4.2472	194	3.7052	200	6.2585	266	3.7146	201	3.7738	204	3.4071	204	4.2383	204
lastIndexOf	27.2224	2438	26.7242	2408	26.5297	2448	36.6855	3260	26.6724	2413	26.8274	2388	26.2273	2409	26.5668	2413
listIterator	4.0923	199	3.8791	197	3.4499	201	4.7948	271	3.5211	198	3.5665	197	3.5485	195	3.8970	200
listIteratori	3.5178	197	4.8897	195	4.1712	197	5.6153	264	4.1498	195	3.7611	196	3.4433	200	3.8707	195
remove	16.7118	1293	16.0287	1296	85.5149	8048	5.2105	243	16.3957	1305	16.9656	1294	15.8466	1297	16.4117	1290
removeAll	800.6362	74570	815.9125	75055	848.7941	77949	829.8120	76059	812.6019	75188	803.4346	74341	811.8826	75083	816.0893	75628
removei	15.7604	1238	15.5615	1238	57.5978	5359	9.4499	731	15.3716	1232	15.9824	1235	15.9731	1225	15.4837	1243
retainAll	191.2629	17515	189.2622	17436	187.5156	17258	189.0232	17346	185.6256	17141	192.1342	17445	246.8980	22740	256.3624	23843
set	4.0179	204	3.8355	207	55.3024	5215	9.4216	757	3.9253	211	3.8588	210	4.1395	208	4.2365	236
sublist	4.1009	203	3.4186	202	3.5210	194	5.3223	272	3.6955	197	3.9814	196	3.7111	194	3.9882	198
toArray	3.6473	200	3.8151	202	3.5124	196	6.5844	273	3.8092	195	3.7162	196	3.7170	195	3.1472	195

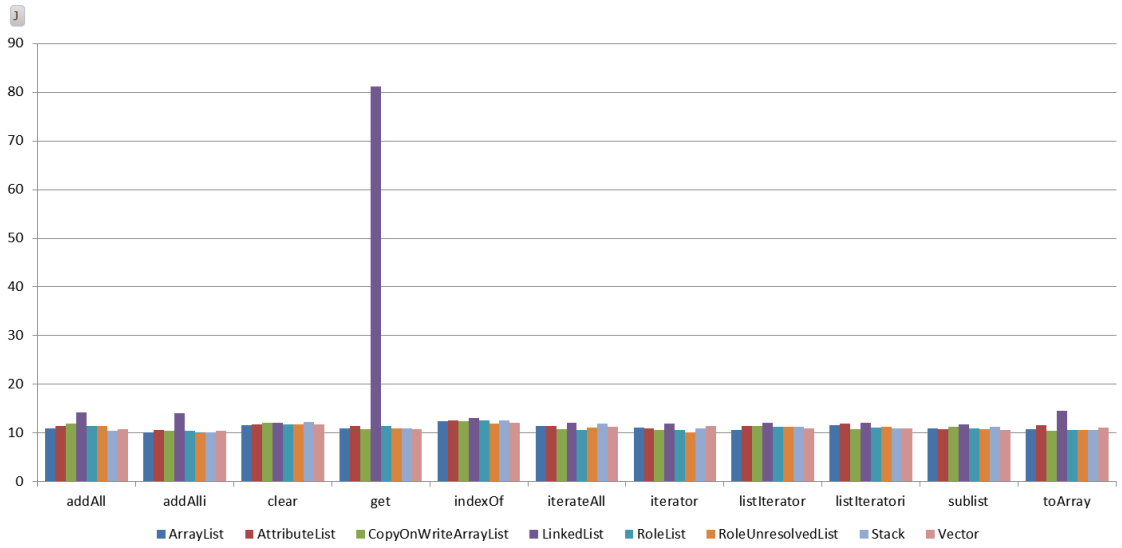


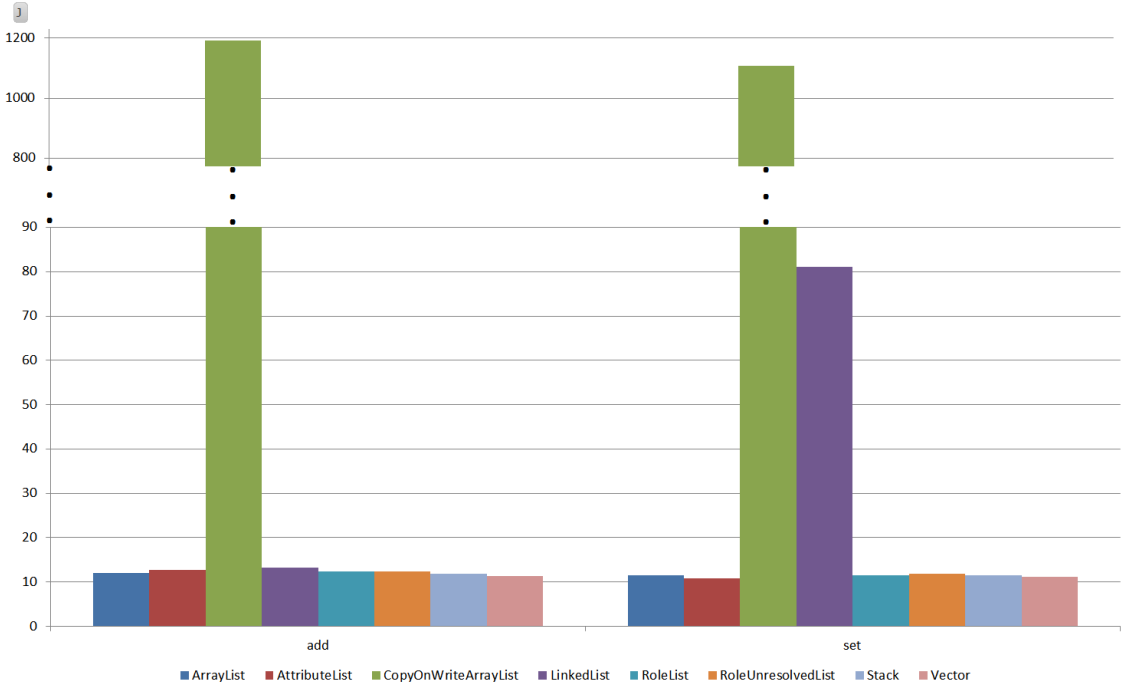

90
80
70
60
50
40
30
20
10
0
add
addI
containsAll
lastIndexOf
remove
removei
set
ArrayList
AttributeList
CopyOnWriteArrayList
LinkedList
RoleList
RoleUnresolvedList
Stack
Vector

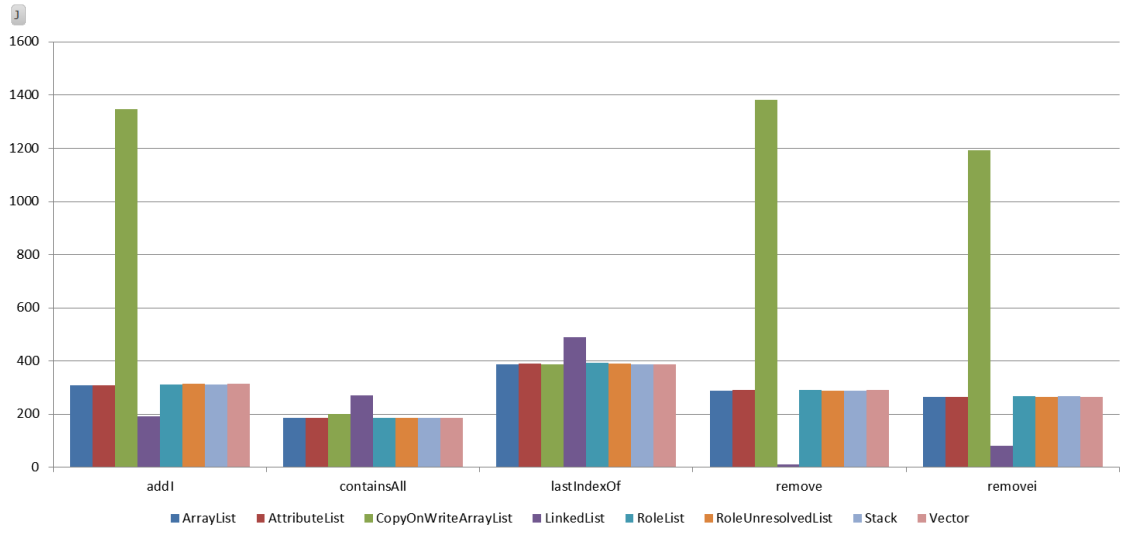

900
800
700
600
500
400
300
200
100
0
contains
removeAll
retainAll
ArrayList
AttributeList
CopyOnWriteArrayList
LinkedList
RoleList
RoleUnresolvedList
Stack
Vector

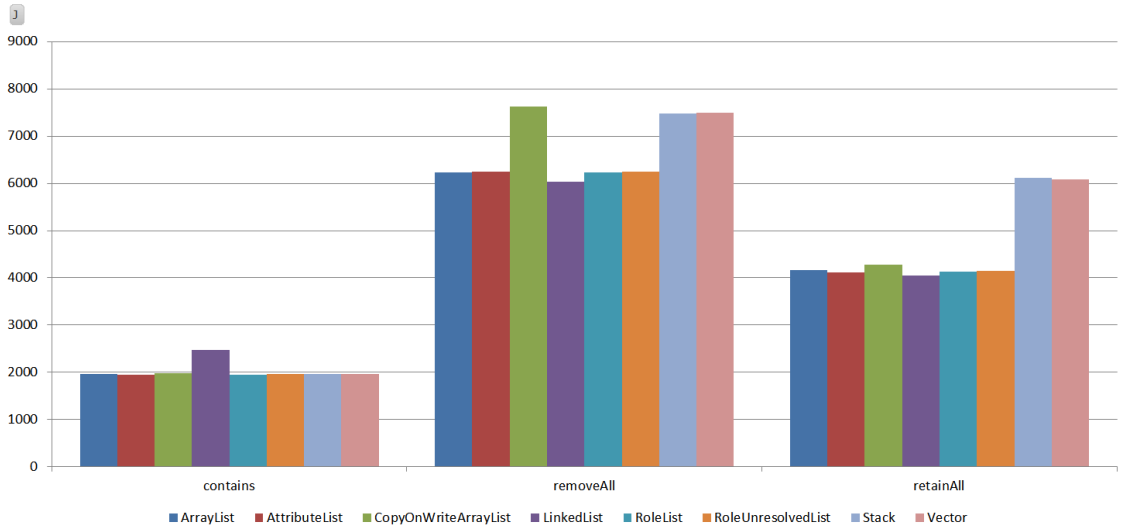
F List data for 1m population

	ArrayList		AttributeList		CopyOn Write		LinkedList		RoleList		Role Unresolved		Stack		Vector	
Methods	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms
add	12.0464	701	12.7195	707	1192.1624	116076	13.1935	728	12.4607	709	12.3262	706	11.7879	722	11.3576	696
addAll	10.9094	648	11.3724	641	11.9216	660	14.2490	817	11.3734	637	11.4211	639	10.4004	642	10.7678	649
addAlli	10.1839	615	10.5913	622	10.5091	634	14.0827	834	10.4132	613	10.0168	611	10.0941	615	10.5229	617
addI	308.6728	28059	308.4402	28070	1347.1859	128466	190.3535	18902	312.4176	28542	313.0971	28577	312.1597	28570	312.8684	28688
clear	11.6159	740	11.7247	730	12.0538	732	12.0858	742	11.6814	738	11.7761	736	12.2983	736	11.7146	736
contains	1970.9064	195324	1952.7448	191984	1979.2615	195337	2466.3537	239826	1950.6017	191656	1959.7723	193343	1957.1560	192235	1968.4488	193401
containsAll	185.4605	17164	185.8306	17224	199.4027	18557	270.4051	24800	185.9840	17178	186.6167	17244	187.1497	17239	186.1992	17221
get	10.9069	616	11.4765	625	10.7958	629	81.1299	8346	11.3632	643	11.0016	626	10.9420	621	10.7961	616
indexOf	12.3355	752	12.5442	752	12.4852	751	13.0304	824	12.5427	758	11.8597	750	12.6218	771	12.1569	764
iterateAll	11.4806	659	11.3767	646	10.8094	646	12.0847	692	10.6485	640	11.0305	644	11.9679	741	11.3126	737
iterator	11.0537	635	10.9354	629	10.6816	624	11.9186	694	10.5633	633	10.0707	622	10.9189	653	11.3553	643
lastIndexOf	387.2730	36766	388.6052	37032	387.0817	37231	489.1250	46240	393.5686	37582	390.2053	37104	386.6704	37474	386.9537	37475
listIterator	10.6885	611	11.4602	631	11.4474	657	12.0396	669	11.3297	629	11.2530	630	11.3042	623	10.8957	615
listIteratori	11.5547	640	11.8432	618	10.8368	629	12.1197	741	11.1662	622	11.3287	643	10.8977	629	10.9616	611
remove	286.8151	25810	289.7602	26253	1382.3727	130720	11.2295	639	290.6235	26322	288.9534	26146	288.1555	25858	290.4005	26330
removeAll	6240.3017	616088	6254.3095	619221	7633.4344	756859	6031.4099	600757	6240.6818	616568	6242.6897	616035	7481.8537	741031	7491.7295	740725
removei	264.0750	23596	264.7749	23789	1193.7827	113704	80.0698	8312	267.6469	24018	263.0561	23579	266.6137	23979	265.2319	23828
retainAll	4165.0922	415147	4108.4192	409992	4285.7077	426197	4046.2904	402778	4125.8655	411737	4143.7322	413506	6116.5527	605233	6083.4340	606689
set	11.5278	653	10.7694	647	1107.5213	107726	81.0687	8381	11.5072	655	11.8232	642	11.4580	673	11.1637	656
sublist	10.9601	611	10.7711	636	11.1858	622	11.7203	676	10.9904	638	10.8467	634	11.3011	636	10.6396	627
toArray	10.7242	612	11.5362	642	10.4389	628	14.5166	796	10.6314	623	10.6248	619	10.6683	614	11.0372	637



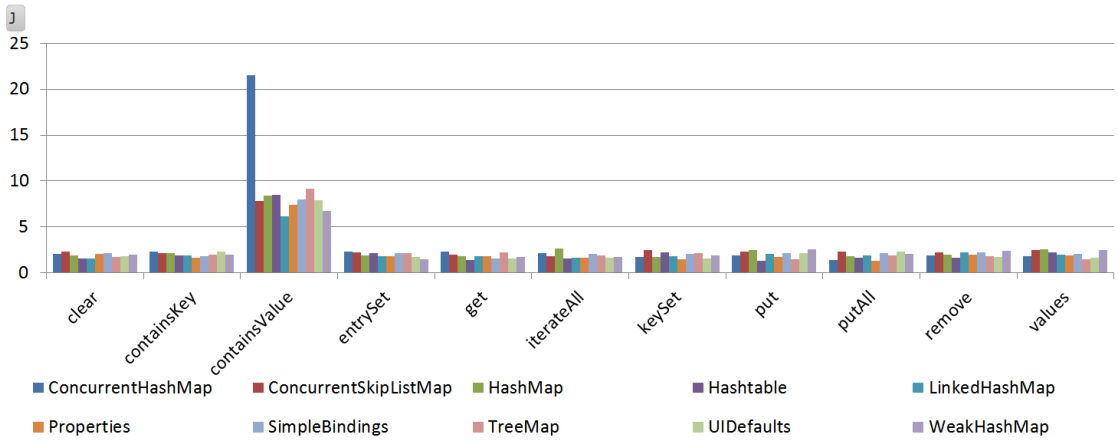

1200
1000
800
90
80
70
60
50
40
30
20
10
0
add
set
ArrayList
AttributeList
CopyOnWriteArrayList
LinkedList
RoleList
RoleUnresolvedList
Stack
Vector


1600
1400
1200
1000
800
600
400
200
0
addI
containsAll
lastIndexOf
remove
removei
ArrayList
AttributeList
CopyOnWriteArrayList
LinkedList
RoleList
RoleUnresolvedList
Stack
Vector


9000
8000
7000
6000
5000
4000
3000
2000
1000
0
contains
removeAll
retainAll
ArrayList
AttributeList
CopyOnWriteArrayList
LinkedList
RoleList
RoleUnresolvedList
Stack
Vector

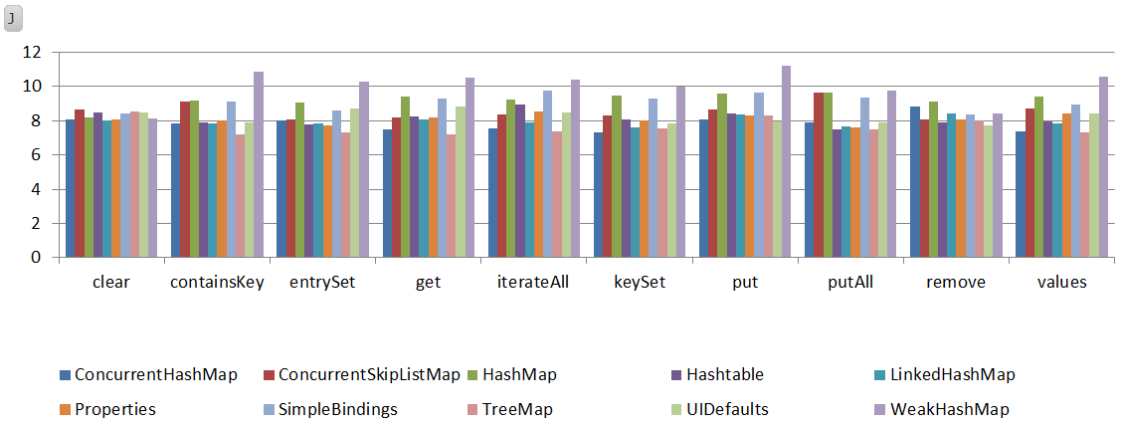
G Map data for 25k population

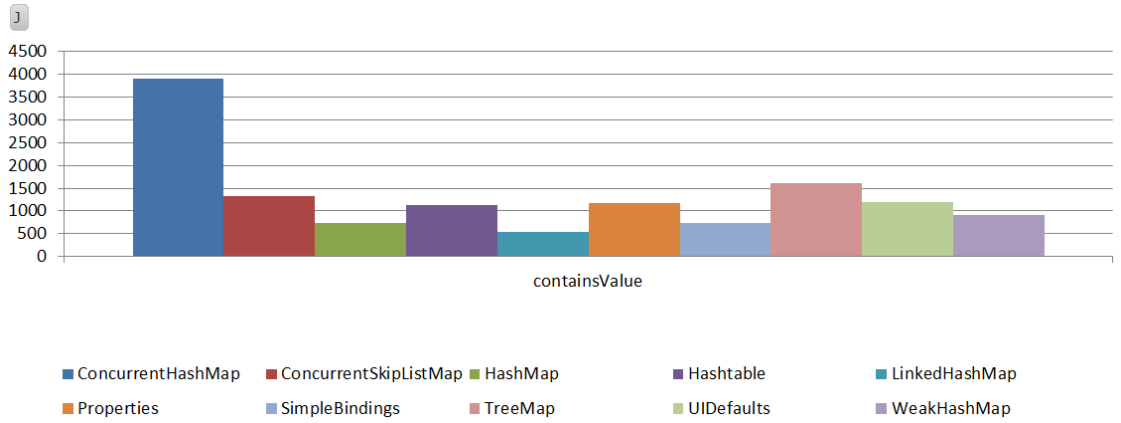
	Concurrent HashMap		Concurrent SkipListMap		HashMap		Hashtable		Linked HashMap		Properties		Simple Bindings		TreeMap		UIDefaults		Weak HashMap	
Methods	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms	J	ms
clear	2.0276	94	2.2961	88	1.8395	104	1.5761	94	1.5025	97	2.0777	98	2.1401	106	1.6706	98	1.8143	105	1.9941	95
containsKey	2.3132	105	2.1693	123	2.1343	103	1.8582	94	1.8726	103	1.6018	107	1.8055	99	1.9452	100	2.3366	89	1.9675	108
containsValue	21.5611	2305	7.8032	643	8.3615	683	8.4957	765	6.1326	462	7.3755	692	7.9912	678	9.1771	847	7.9341	714	6.7072	562
entrySet	2.2878	93	2.2363	116	1.8531	108	2.1332	107	1.8362	113	1.7800	97	2.1557	102	2.1617	115	1.7087	105	1.4666	102
get	2.3106	103	1.9972	119	1.8120	102	1.4071	100	1.8252	116	1.7851	97	1.5359	100	2.2331	115	1.5252	89	1.7185	103
iterateAll	2.1041	96	1.8353	115	2.6673	100	1.5343	91	1.6462	111	1.6362	100	2.0472	116	1.9122	111	1.6574	95	1.7139	106
keySet	1.7287	95	2.4889	124	1.6813	114	2.2226	99	1.8328	103	1.4866	92	2.0630	106	2.1680	110	1.5547	99	1.8749	105
put	1.8591	104	2.2888	102	2.4628	92	1.3123	96	2.0338	108	1.7038	107	2.1646	102	1.4355	91	2.1204	93	2.5784	105
putAll	1.4147	95	2.2852	122	1.7564	100	1.5949	105	1.8608	113	1.3097	95	2.1461	112	1.8914	116	2.3094	87	2.0750	108
remove	1.8574	92	2.2131	105	1.9256	109	1.6067	97	2.2300	106	1.9660	98	2.2178	106	1.8133	101	1.6888	92	2.4103	103
values	1.8279	85	2.4690	116	2.5755	109	2.2266	94	2.0009	107	1.9120	111	2.0692	108	1.4467	105	1.6533	100	2.4628	111

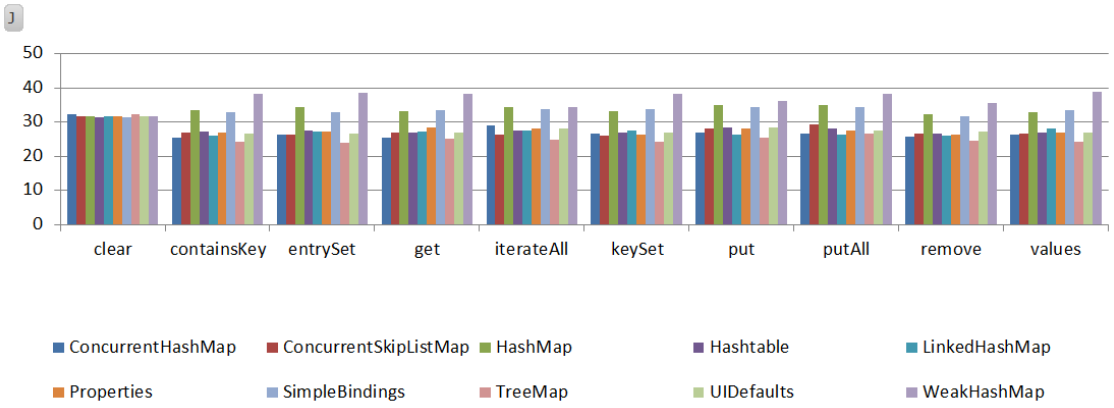
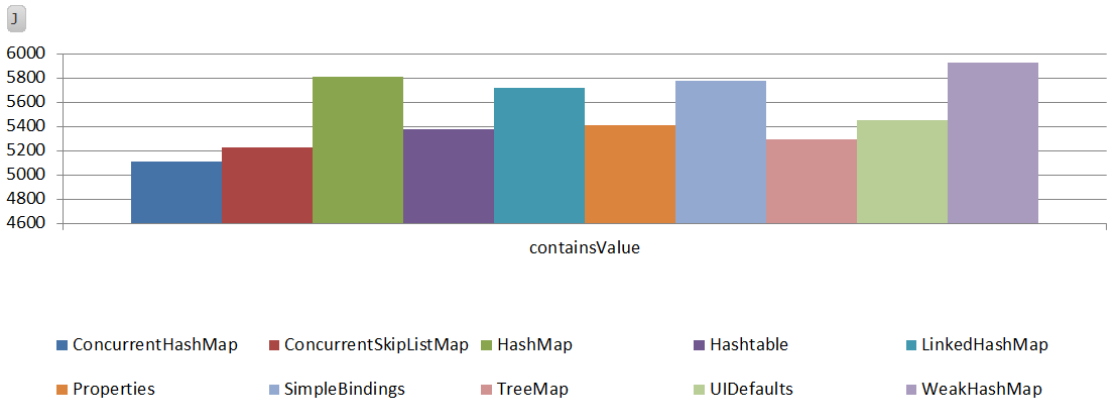


H Map data for 250k population

Methods	Concurrent HashMap J	ms	Concurrent SkipList Map J	ms	HashMap J	ms	Hashtable J	ms	Linked HashMap J	ms	Properties J	ms	Simple Bindings J	ms	TreeMap J	ms	UIDefaults J	ms	Weak HashMap J	ms
clear	8.0929	532	8.6506	548	8.2128	526	8.4732	522	7.9924	518	8.0495	529	8.4215	516	8.5468	543	8.4711	527	8.1116	522
containsKey	7.8434	426	9.1539	473	9.1804	550	7.8745	451	7.8521	429	8.0387	451	9.1259	536	7.1873	415	7.9168	452	10.8584	610
containsValue	3911.4124	461730	1334.8256	154701	730.9166	75444	1128.1868	127397	545.2480	55788	1166.8370	131071	745.1696	76840	1606.2652	183898	1204.5573	136323	912.0360	91357
entrySet	8.0325	434	8.0541	466	9.0436	547	7.8135	438	7.8607	441	7.7498	442	8.6253	540	7.3000	399	8.7348	440	10.3130	621
get	7.4986	434	8.1773	465	9.4016	546	8.2263	449	8.0936	419	8.1691	453	9.3113	542	7.2236	415	8.8114	442	10.4985	621
iterateAll	7.5645	487	8.3979	494	9.2449	570	8.9272	477	7.8789	451	8.5419	477	9.7741	562	7.3954	452	8.5096	475	10.4295	630
keySet	7.3338	436	8.2838	456	9.4461	570	8.0567	448	7.5861	433	8.0351	452	9.3002	533	7.5795	415	7.8576	455	9.9974	614
put	8.0530	458	8.6610	467	9.5894	576	8.4029	452	8.3766	432	8.3302	448	9.6672	557	8.2926	421	7.9345	450	11.2110	633
putAll	7.9165	460	9.6607	566	9.6678	562	7.4861	443	7.6870	421	7.6266	441	9.3364	550	7.5239	470	7.9134	451	9.7825	626
remove	8.8059	455	8.0675	474	9.1076	545	7.9131	437	8.4532	422	8.1008	443	8.3784	531	8.0151	437	7.7442	447	8.4500	533
values	7.3602	440	8.7056	463	9.4056	571	7.9879	450	7.8246	438	8.4208	441	8.9347	548	7.3330	415	8.4531	451	10.5991	615





I Map data for 1m population

Methods	Concurrent HashMap J	ms	Concurrent SkipList Map J	ms	HashMap J	ms	Hashtable J	ms	Linked HashMap J	ms	Properties J	ms	Simple Bindings J	ms	TreeMap J	ms	UIDefaults J	ms	Weak HashMap J	ms
clear	32.1468	2086	31.6883	2020	31.6585	1997	31.4659	2009	31.7548	2002	31.6198	2018	31.3525	1978	32.2024	2015	31.6685	2018	31.7730	1992
containsKey	25.3230	1645	27.0269	1707	33.4752	2056	27.0329	1615	26.1077	1585	26.8887	1634	32.9557	2026	24.2985	1539	26.4794	1615	38.1398	2362
containsValue	5110.1689	602187	5223.6619	602035	5809.9971	602007	5377.3805	602040	5719.4071	602019	5408.3341	602026	5781.2350	602023	5291.3279	602031	5454.6906	602028	5931.2509	602055
entrySet	26.2053	1631	26.3433	1630	34.2838	2108	27.4266	1637	27.3013	1625	27.1060	1621	32.9119	2043	23.8757	1478	26.7149	1624	38.6346	2417
get	25.4475	1658	26.8225	1668	33.0373	2060	26.7896	1603	27.0924	1605	28.3008	1683	33.4063	2061	25.0432	1545	26.9511	1601	38.2429	2357
iterateAll	29.0126	1931	26.4318	1701	34.3681	2158	27.3898	1701	27.3926	1655	27.9918	1717	33.7128	2100	24.8704	1627	28.1027	1702	34.2753	2250
keySet	26.4697	1654	26.1301	1613	33.2621	2041	27.0295	1634	27.3374	1638	26.3382	1621	33.7798	2055	24.1255	1502	27.0168	1618	38.2719	2376
put	27.0194	1759	28.0145	1745	34.9660	2168	28.3543	1712	26.1753	1552	28.0086	1731	34.3807	2141	25.3354	1587	28.5027	1712	36.0024	2211
putAll	26.5031	1764	29.3885	2020	35.0481	2174	28.0358	1704	26.2283	1580	27.5977	1682	34.2556	2121	26.6613	1725	27.4983	1673	38.2742	2380
remove	25.5665	1667	26.6545	1694	32.3202	1973	26.4978	1591	25.9951	1581	26.2373	1598	31.6204	1937	24.4253	1530	27.1669	1612	35.4727	2158
values	26.3867	1663	26.6376	1632	32.8656	2033	26.9196	1630	28.2103	1628	26.8990	1621	33.3910	2052	24.2967	1477	26.7752	1639	38.9120	2413