

Appendix: Is Seeding a Good Strategy in Multi-objective Feature Selection When Feature Models Evolve?

Takfarinas Saber^{a,*}, David Brevet^b, Goetz Botterweck^c, Anthony Ventresque^{a,*}

^a*Lero@UCD, School of Computer Science, University College Dublin, Dublin 4, Ireland*

^b*Institut Supérieur d'Informatique, de Modélisation et de leurs Applications, Clermont-Ferrand, France*

^c*Lero@UL, University of Limerick, Ireland*

*Corresponding authors

Email addresses: takfarinas.saber@ucdconnect.ie (Takfarinas Saber), david.brevet@isima.fr (David Brevet), goetz.botterweck@lero.ie (Goetz Botterweck), anthony.ventresque@ucd.ie (Anthony Ventresque)

Appendix A. Performance of SATIBEA and eSATIBEA on eCos

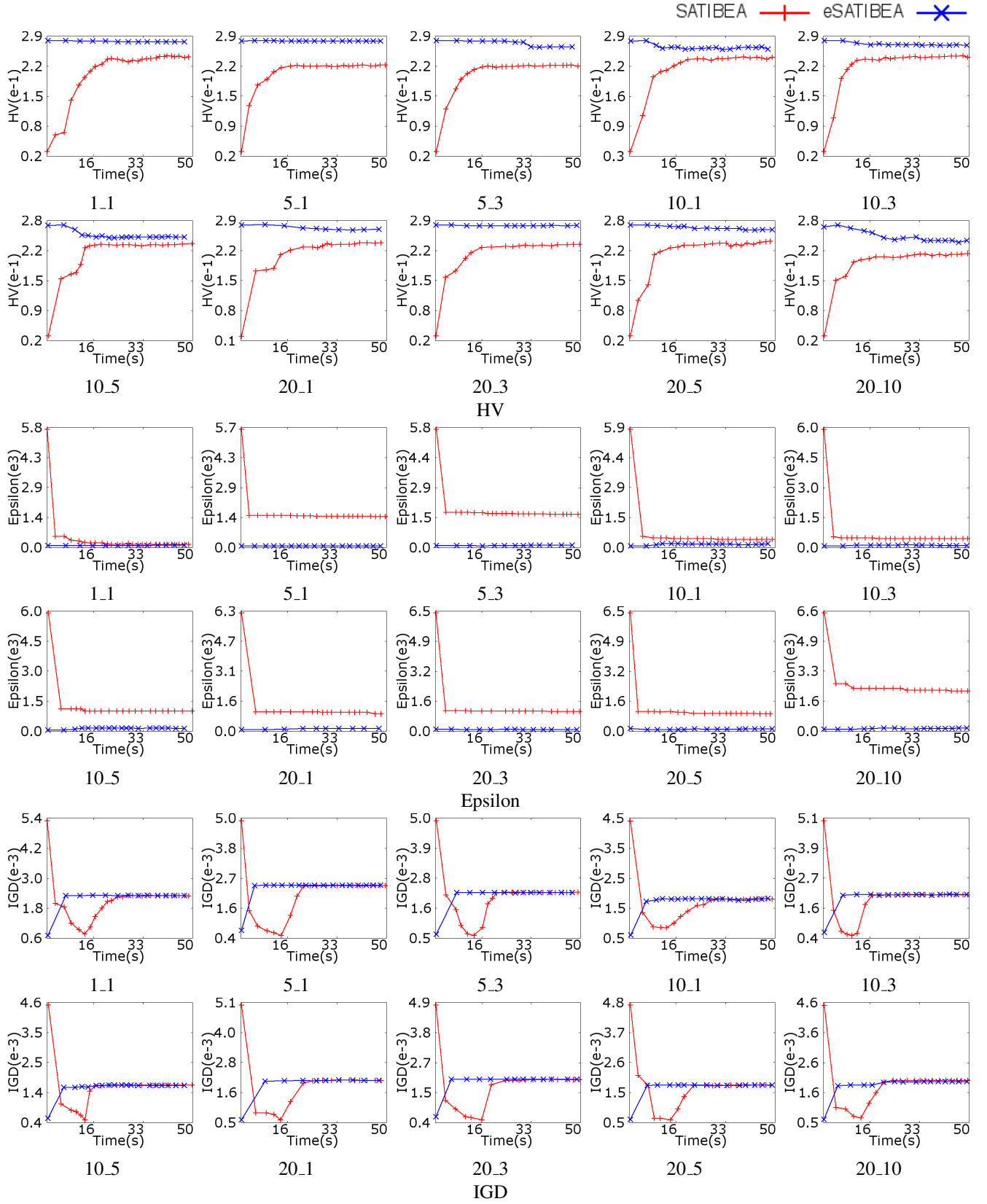


Figure A.1: Evolution of the quality of SATIBEA's and eSATIBEA's solutions for the eCos data set.

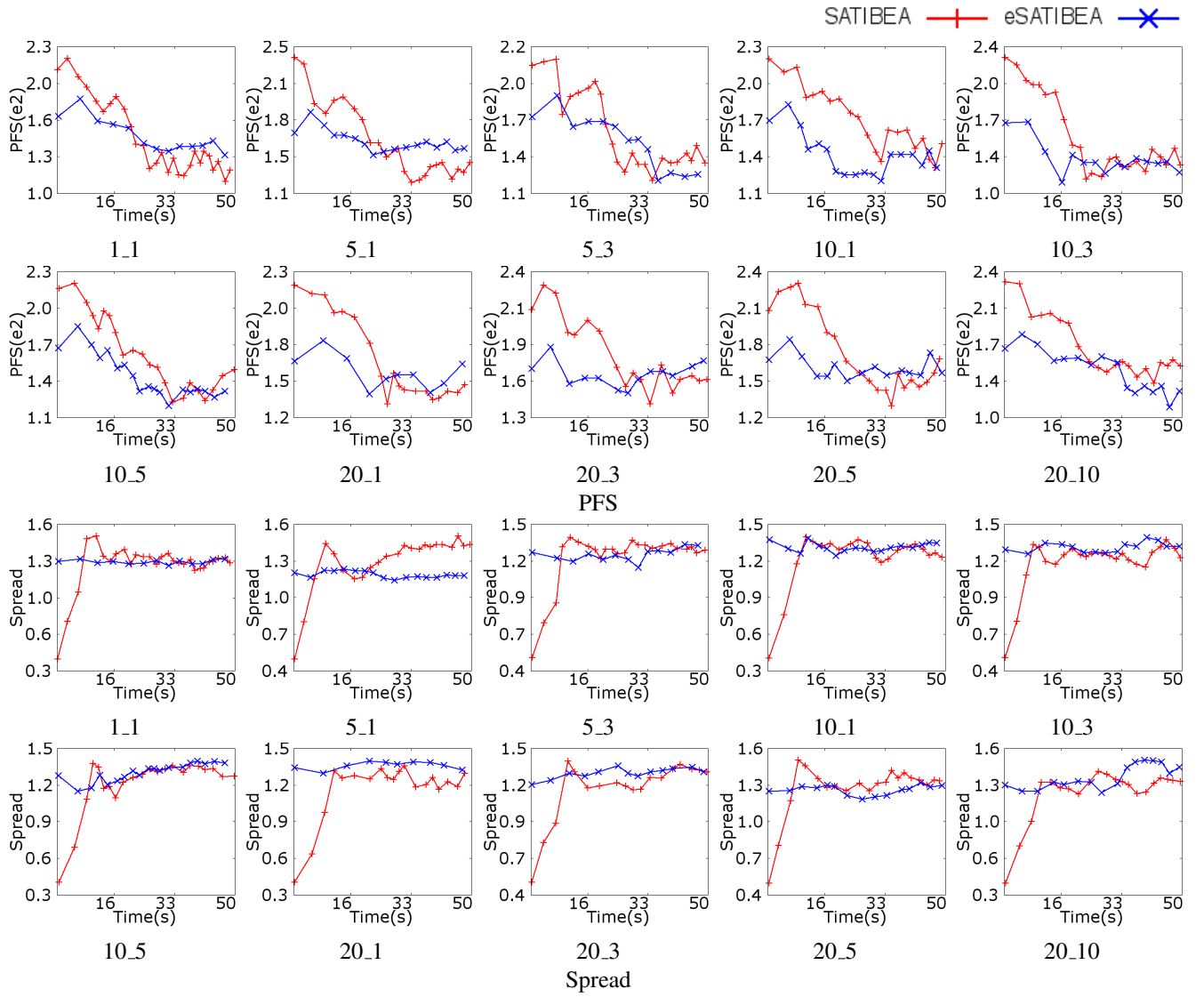


Figure A.2: Evolution of the diversity of SATIBEA and eSATIBEA's solutions for the eCos data set.

Table A.1: Evaluation of the performance of eSATIBEA vs. SATIBEA on the different targets of the eCos data set in four optimisation snapshots(i.e., initial, first, middle and last generations) using five different metrics (i.e., HV, ϵ , IGD, PFS and Spread). We also report the significance of eSATIBEA's results in comparison to those of SATIBEA at each of the four snapshots by means of MWU and \hat{A}_{12} .

Target	Metric	SATIBEA				eSATIBEA				Sig Init		Sig First		Sig Middle		Sig Last	
		Init	First	Middle	Last	Init	First	Middle	Last	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}
1.1	HV (e-2)	2.816	6.572	22.780	23.925	27.480	27.535	27.260	27.276	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	566.256	53.700	19.800	14.700	8.945	8.945	10.000	10.500	6.06E-13	1.00	2.01E-12	1.00	1.21E-11	1.00	2.18E-11	1.00
	IGD (e-4)	52.579	19.854	22.891	22.790	7.079	22.939	22.992	22.947	1.51E-11	1.00	1.99E-04	0.23	1.51E-11	0.00	3.69E-11	0.01
	PFS (e2)	2.070	2.170	1.270	1.210	1.670	1.820	1.390	1.340	7.44E-12	0.00	1.44E-11	0.00	2.44E-11	0.01	1.09E-02	0.67
	S (e-1)	4.393	7.588	12.420	12.511	12.635	12.860	12.724	12.852	1.51E-11	1.00	1.51E-11	1.00	3.86E-02	0.63	4.38E-01	0.49
5.1	HV (e-2)	3.332	13.354	22.015	22.192	27.462	27.518	27.417	27.444	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	563.083	152.428	149.199	147.710	7.300	7.200	7.200	7.100	6.06E-13	1.00	4.67E-12	1.00	1.42E-11	1.00	1.39E-11	1.00
	IGD (e-4)	48.623	14.541	23.993	24.048	7.112	24.100	24.262	24.273	1.51E-11	1.00	5.54E-07	0.13	1.51E-11	0.00	1.51E-11	0.00
	PFS (e2)	2.370	2.310	1.540	1.410	1.680	1.870	1.510	1.540	2.57E-12	0.00	1.41E-11	0.00	4.38E-06	0.17	6.70E-10	0.96
	S (e-1)	4.553	7.632	13.261	14.077	11.719	11.319	11.285	11.472	1.51E-11	1.00	1.51E-11	1.00	3.69E-11	0.01	1.51E-11	0.00
5.3	HV (e-2)	2.897	12.460	21.945	22.056	27.691	27.759	27.360	26.358	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	571.406	170.628	165.077	160.593	9.200	9.200	9.200	12.112	6.06E-13	1.00	5.51E-12	1.00	1.45E-11	1.00	1.50E-11	1.00
	IGD (e-4)	48.902	21.407	22.272	22.287	6.742	22.257	22.112	22.260	1.51E-11	1.00	4.24E-09	0.07	1.51E-11	0.00	2.14E-01	0.56
	PFS (e2)	2.100	2.130	1.330	1.320	1.690	1.860	1.500	1.230	5.41E-12	0.00	1.43E-11	0.00	1.49E-11	0.00	4.30E-01	0.51
	S (e-1)	4.891	7.524	12.714	12.993	12.836	12.404	12.294	13.363	1.51E-11	1.00	1.51E-11	1.00	1.00E-01	0.60	1.03E-01	0.40
10.1	HV (e-2)	3.529	11.303	23.277	23.965	27.465	27.550	25.893	25.689	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	579.552	55.552	43.902	39.868	7.900	7.300	17.800	18.800	6.06E-13	1.00	2.06E-12	1.00	1.50E-11	1.00	1.50E-11	1.00
	IGD (e-4)	44.297	13.186	17.387	17.818	5.597	17.063	17.931	18.027	1.51E-11	1.00	1.35E-02	0.33	1.42E-08	0.08	5.86E-03	0.31
	PFS (e2)	2.200	2.090	1.570	1.500	1.690	1.820	1.240	1.300	3.18E-12	0.00	1.47E-11	0.00	4.00E-11	0.01	3.78E-01	0.52
	S (e-1)	4.411	7.798	13.422	12.292	13.667	12.958	13.060	13.419	1.51E-11	1.00	1.51E-11	1.00	9.37E-08	0.89	2.18E-02	0.65
10.3	HV (e-2)	2.923	10.425	23.731	23.871	27.590	27.595	26.597	26.567	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	594.063	54.395	45.514	44.479	7.200	7.200	15.500	9.400	1.18E-12	1.00	3.23E-12	1.00	1.49E-11	1.00	1.49E-11	1.00
	IGD (e-4)	49.517	14.897	20.842	20.842	6.313	20.680	20.924	21.004	1.51E-11	1.00	3.81E-03	0.30	4.96E-11	0.01	2.98E-09	0.06
	PFS (e2)	2.280	2.210	1.220	1.300	1.680	1.690	1.220	1.230	1.56E-12	0.00	1.44E-11	0.00	1.49E-11	0.00	9.34E-03	0.32
	S (e-1)	4.807	7.508	12.620	12.310	12.891	12.591	12.665	13.147	1.51E-11	1.00	1.51E-11	1.00	3.14E-06	0.84	4.33E-05	0.80
10.5	HV (e-2)	2.975	15.541	22.876	23.203	27.165	27.304	24.564	24.691	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	593.096	112.128	101.784	100.341	6.700	6.700	14.800	14.000	1.18E-12	1.00	3.93E-12	1.00	1.50E-11	1.00	1.50E-11	1.00
	IGD (e-4)	45.013	10.332	16.909	16.973	5.375	16.111	17.020	16.888	1.51E-11	1.00	9.76E-04	0.27	3.14E-06	0.16	4.38E-01	0.49
	PFS (e2)	2.170	2.210	1.620	1.490	1.670	1.850	1.350	1.310	1.56E-12	0.00	1.45E-11	0.00	9.12E-10	0.05	2.76E-03	0.29
	S (e-1)	4.498	7.289	13.131	12.969	13.026	11.794	13.599	14.021	1.51E-11	1.00	1.51E-11	1.00	1.45E-03	0.72	2.42E-02	0.65
20.1	HV (e-2)	2.301	17.115	22.802	23.549	27.590	27.633	26.766	26.631	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	616.588	100.289	99.201	90.646	8.500	8.500	13.500	13.400	1.58E-12	1.00	3.93E-12	1.00	1.50E-11	1.00	1.50E-11	1.00
	IGD (e-4)	50.109	8.660	21.105	21.091	5.968	20.837	20.961	21.136	1.51E-11	1.00	3.98E-03	0.30	1.51E-11	0.00	3.60E-05	0.20
	PFS (e2)	2.210	2.150	1.570	1.490	1.660	1.810	1.530	1.640	2.02E-12	0.00	1.38E-11	0.00	1.48E-11	0.00	7.76E-03	0.32
	S (e-1)	4.487	6.709	12.548	13.020	13.462	13.035	13.903	13.297	1.51E-11	1.00	1.51E-11	1.00	3.99E-02	0.63	9.34E-06	0.82
20.3	HV (e-2)	2.662	15.832	22.670	23.211	27.546	27.563	27.348	27.403	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	637.748	110.028	108.124	106.216	10.200	10.200	9.900	8.900	6.06E-13	1.00	8.33E-12	1.00	1.48E-11	1.00	1.50E-11	1.00
	IGD (e-4)	48.398	12.338	19.968	20.245	6.192	20.407	20.413	20.385	1.51E-11	1.00	4.76E-06	0.17	1.51E-11	0.00	2.25E-11	0.00
	PFS (e2)	2.120	2.300	1.550	1.600	1.680	1.840	1.500	1.740	3.85E-12	0.00	1.46E-11	0.00	3.04E-11	0.01	2.63E-03	0.71
	S (e-1)	4.620	7.768	12.269	13.367	12.368	12.723	13.283	13.376	1.51E-11	1.00	1.51E-11	1.00	2.63E-04	0.76	4.39E-02	0.37
20.5	HV (e-2)	2.691	10.594	23.211	23.706	27.300	27.365	26.629	26.283	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	639.283	105.888	95.602	93.984	13.600	9.100	9.600	11.700	6.06E-13	1.00	1.33E-11	1.00	1.48E-11	1.00	1.50E-11	1.00
	IGD (e-4)	46.655	21.481	17.785	17.974	5.709	17.960	17.990	18.017	1.51E-11	1.00	4.16E-03	0.30	1.19E-10	0.02	2.90E-01	0.54
	PFS (e2)	2.070	2.230	1.470	1.660	1.650	1.820	1.540	1.540	2.57E-12	0.00	1.45E-11	0.00	3.63E-11	0.01	3.45E-01	0.53
	S (e-1)	4.649	7.886	12.538	13.401	12.523	12.546	11.814	12.992	1.51E-11	1.00	1.51E-11	1.00	1.86E-01	0.57	4.15E-01	0.48
20.1	HV (e-2)	2.725	14.980	20.382	20.927	26.753	27.213	24.324	23.742	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	64.584	25.940	22.373	21.894	1.050	1.050	1.360	1.610	6.06E-13	1.00	1.41E-11	1.00	1.51E-11	1.00	1.49E-11	1.00
	IGD (e-4)	45.301	10.481	19.713	19.668	6.290	17.761	19.094	19.240	1.51E-11	1.00	1.86E-01	0.43	2.37E-06	0.16	1.51E-11	1.00
	PFS (e2)	2.340	2.320	1.450	1.510	1.680	1.820	1.600	1.260	8.04E-12	0.00	1.44E-11	0.00	2.82E-11	0.01	3.33E-02	0.36
	S (e-1)	4.385	7.505	13.564	12.965	12.652	12.125	11.993	14.156	1.51E-11	1.00	1.51E-11	1.00	7.03E-05	0.79	1.89E-02	0.66

Appendix B. Performance of SATIBEA and eSATIBEA on Fiasco

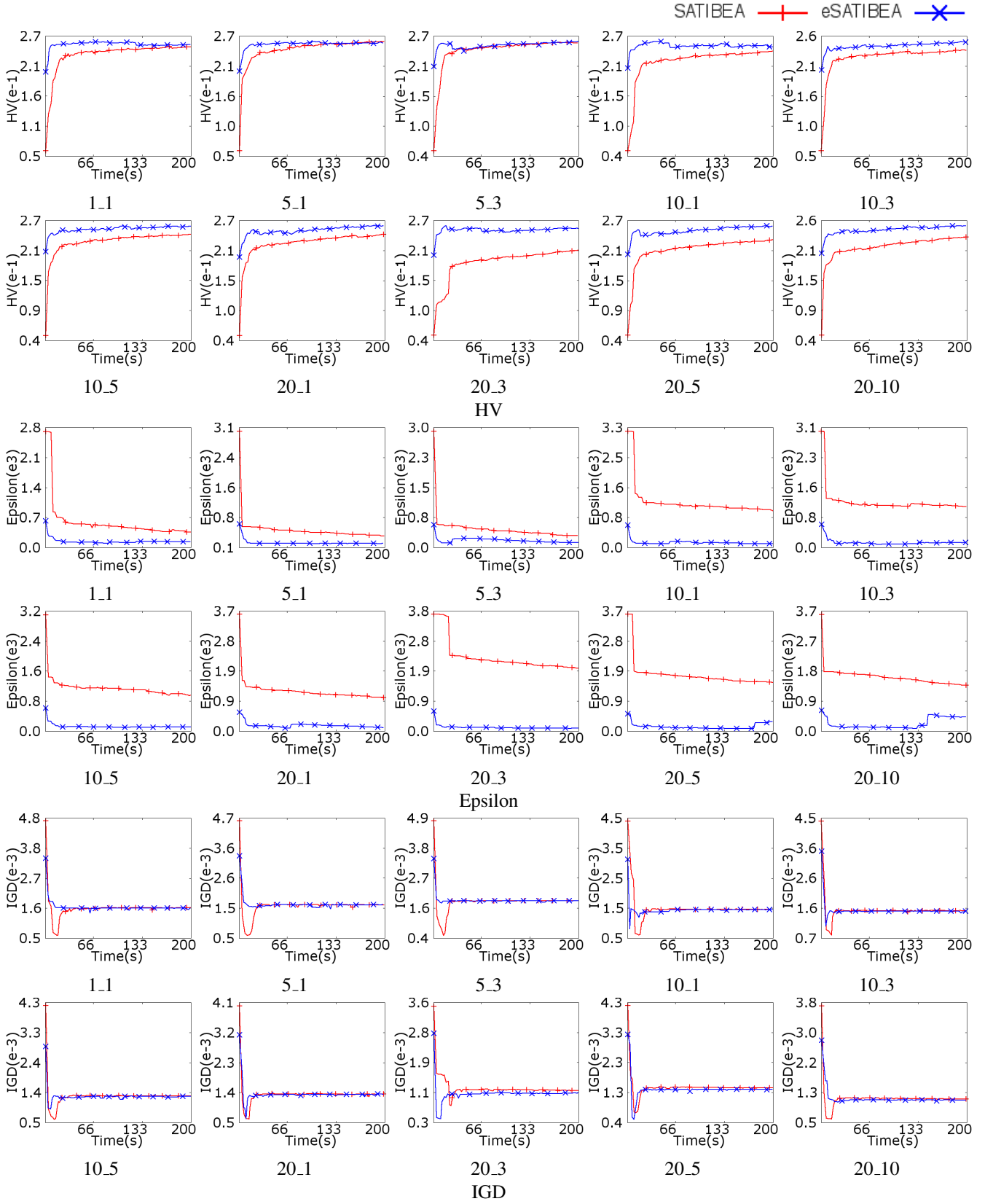


Figure B.3: Evolution of the quality of SATIBEA's and eSATIBEA's solutions for the Fiasco data set.

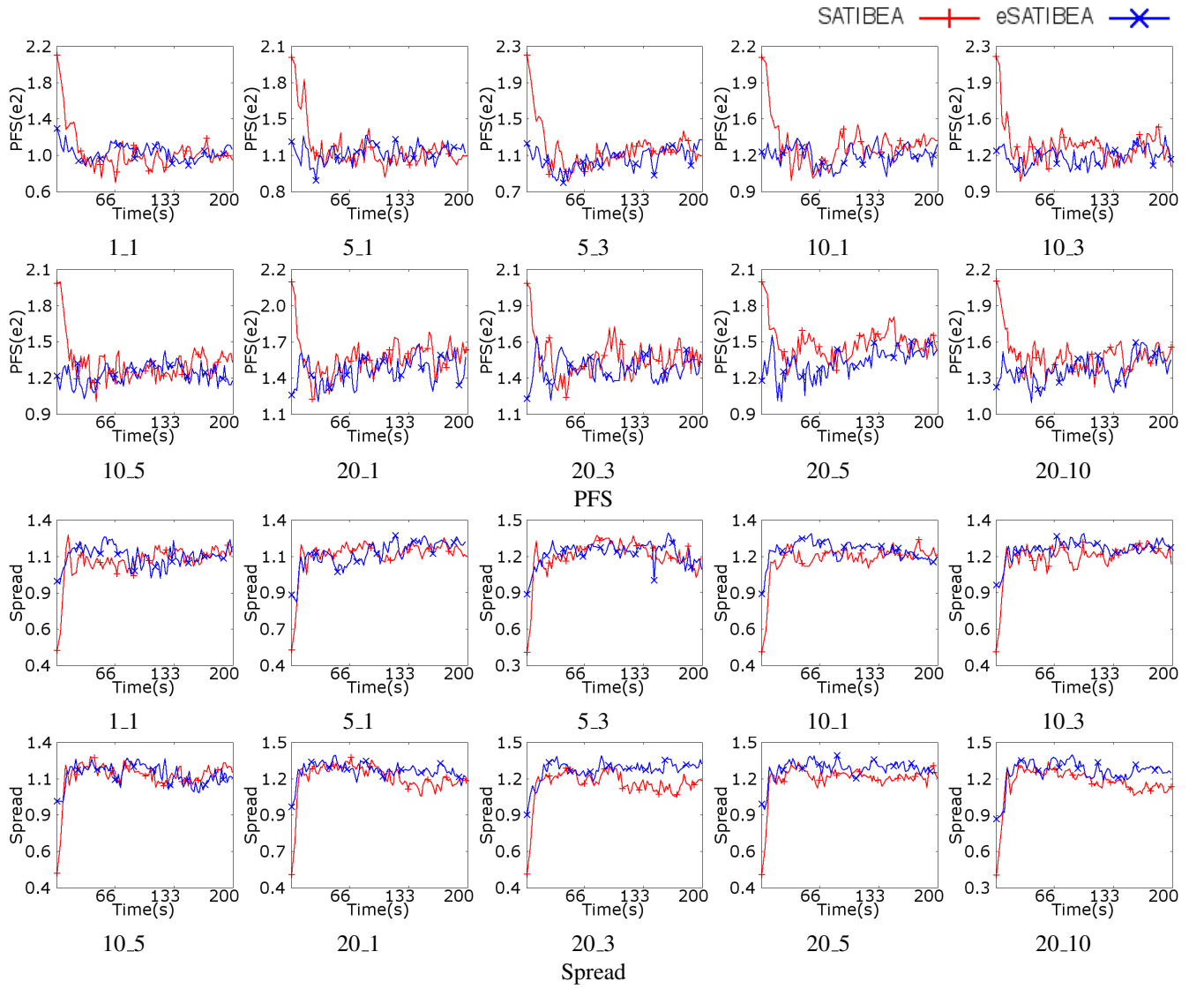


Figure B.4: Evolution of the diversity of SATIBEA and eSATIBEA's solutions for the Fiasco data set.

Table B.2: Evaluation of the performance of eSATIBEA vs. SATIBEA on the different targets of the Fiasco data set in four optimisation snapshots(i.e., initial, first, middle and last generations) using five different metrics (i.e., HV, ϵ , IGD, PFS and Spread). We also report the significance of eSATIBEA's results in comparison to those of SATIBEA at each of the four snapshots by means of MWU and \hat{A}_{12} .

Target	Metric	SATIBEA				eSATIBEA				Sig Init		Sig First		Sig Middle		Sig Last	
		Init	First	Middle	Last	Init	First	Middle	Last	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}
1.1	HV (e-2)	6.144	12.710	24.335	24.923	20.378	21.843	25.658	25.358	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.44E-10	0.97
	ϵ (e2)	27.256	27.256	5.156	3.860	6.450	3.180	1.360	1.595	1.19E-11	1.00	1.51E-11	1.00	1.46E-11	1.00	1.84E-11	1.00
	IGD (e-3)	4.742	1.835	1.595	1.594	3.390	2.069	1.588	1.582	1.51E-11	1.00	1.17E-01	0.41	2.66E-03	0.71	1.59E-03	0.72
	PFS (e1)	20.700	18.500	9.200	9.100	12.600	11.500	10.500	10.300	1.17E-12	0.00	1.46E-11	0.00	1.87E-01	0.57	4.15E-01	0.52
	S (e-1)	5.000	6.125	11.614	12.004	9.659	9.531	11.412	11.656	1.51E-11	1.00	1.51E-11	1.00	3.26E-01	0.53	3.15E-01	0.46
5.1	HV (e-2)	5.722	18.995	25.127	25.831	20.404	24.060	25.861	25.607	1.51E-11	1.00	1.51E-11	1.00	7.32E-11	0.98	1.13E-03	0.73
	ϵ (e2)	30.344	5.877	4.405	3.515	6.560	2.790	1.520	1.569	1.50E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	IGD (e-3)	4.586	1.274	1.638	1.626	3.354	1.716	1.540	1.632	1.51E-11	1.00	9.29E-02	0.40	9.18E-03	0.68	4.81E-02	0.37
	PFS (e2)	2.010	1.940	1.090	1.120	1.250	1.130	1.150	1.150	8.52E-13	0.00	1.46E-11	0.00	4.44E-01	0.49	1.24E-01	0.41
	S (e-1)	5.360	6.875	11.473	11.406	8.918	8.458	10.934	12.353	1.51E-11	1.00	1.51E-11	1.00	1.00E-01	0.60	5.77E-02	0.62
5.3	HV (e-2)	5.371	13.522	24.773	25.328	20.958	23.937	24.974	25.611	1.51E-11	1.00	1.51E-11	1.00	2.37E-06	0.84	1.13E-03	0.73
	ϵ (e2)	29.310	6.102	4.403	3.296	5.930	2.500	2.094	1.523	3.24E-12	1.00	6.03E-11	0.98	1.51E-11	1.00	1.51E-11	1.00
	IGD (e-3)	4.846	1.253	1.834	1.835	3.423	1.888	1.836	1.834	1.51E-11	1.00	6.48E-02	0.39	2.10E-02	0.65	3.81E-01	0.52
	PFS (e2)	2.220	1.970	1.110	1.110	1.250	1.170	1.130	1.290	6.03E-13	0.00	1.44E-11	0.00	4.03E-02	0.63	4.44E-01	0.51
	S (e-1)	4.433	6.559	12.411	11.670	8.906	9.709	12.822	10.851	1.51E-11	1.00	1.51E-11	1.00	3.26E-01	0.53	3.31E-01	0.53
10.1	HV (e-2)	4.993	8.710	23.012	24.002	20.754	23.737	25.015	24.821	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	31.740	31.740	11.508	10.171	6.270	3.380	1.550	1.214	5.50E-12	1.00	1.51E-11	1.00	1.50E-11	1.00	1.51E-11	1.00
	IGD (e-4)	43.590	26.593	14.643	14.626	31.044	8.169	14.509	14.518	1.51E-11	1.00	3.86E-02	0.63	1.98E-08	0.91	1.51E-07	0.89
	PFS (e2)	2.090	2.040	1.330	1.360	1.260	1.200	1.240	1.320	6.01E-13	0.00	1.48E-11	0.00	1.07E-01	0.41	1.68E-02	0.34
	S (e-1)	4.709	6.276	11.723	11.801	8.922	9.290	12.224	11.625	1.51E-11	1.00	1.51E-11	1.00	2.14E-01	0.56	2.46E-01	0.55
10.3	HV (e-2)	5.872	12.274	23.246	23.827	20.266	22.701	24.631	25.264	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	300.077	299.442	109.063	105.248	60.300	43.700	9.369	12.679	7.22E-12	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	IGD (e-3)	4.406	2.458	1.566	1.567	3.450	2.135	1.548	1.548	1.51E-11	1.00	3.99E-02	0.63	1.91E-10	0.97	9.25E-09	0.92
	PFS (e2)	2.170	2.080	1.320	1.110	1.260	1.300	1.050	1.180	5.94E-13	0.00	1.48E-11	0.00	7.45E-02	0.39	3.43E-02	0.36
	S (e-1)	4.738	6.543	11.514	11.161	9.645	9.454	12.733	12.359	1.51E-11	1.00	1.51E-11	1.00	2.51E-02	0.65	2.11E-03	0.72
10.5	HV (e-2)	4.657	16.969	23.394	24.206	20.810	23.585	25.749	25.743	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	30.524	14.153	11.265	9.449	6.040	2.620	1.030	1.115	7.21E-12	1.00	1.51E-11	1.00	1.50E-11	1.00	1.51E-11	1.00
	IGD (e-4)	41.645	8.910	12.987	13.046	28.726	9.211	11.953	12.888	1.51E-11	1.00	6.37E-03	0.69	8.74E-06	0.82	1.78E-04	0.77
	PFS (e2)	1.980	1.990	1.290	1.360	1.250	1.140	1.360	1.210	5.99E-13	0.00	1.49E-11	0.00	2.02E-01	0.44	1.07E-05	0.18
	S (e-1)	4.740	6.758	11.650	11.747	9.718	9.737	11.964	11.362	1.51E-11	1.00	1.51E-11	1.00	1.63E-02	0.66	3.31E-01	0.47
20.1	HV (e-2)	4.811	16.049	23.171	24.342	19.987	22.535	25.220	25.981	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	36.445	15.810	11.882	10.560	5.970	5.250	2.165	1.228	1.50E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	IGD (e-3)	4.007	1.144	1.331	1.324	3.120	1.958	1.284	1.316	1.51E-11	1.00	7.21E-03	0.68	7.79E-09	0.93	3.89E-09	0.93
	PFS (e2)	2.140	2.030	1.460	1.600	1.240	1.290	1.530	1.540	8.52E-13	0.00	1.46E-11	0.00	1.42E-02	0.34	3.21E-01	0.54
	S (e-1)	4.777	7.241	12.720	11.846	9.886	10.514	12.798	12.123	1.51E-11	1.00	1.51E-11	1.00	7.68E-02	0.61	5.61E-03	0.69
20.3	HV (e-2)	4.753	10.568	19.827	21.086	20.134	24.024	24.559	25.253	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	365.235	365.235	215.525	196.306	63.200	19.800	11.200	9.096	1.50E-11	1.00	1.51E-11	1.00	1.50E-11	1.00	1.51E-11	1.00
	IGD (e-4)	34.817	16.474	12.065	11.899	27.390	4.469	11.271	11.187	1.51E-11	1.00	8.18E-06	0.82	1.51E-11	1.00	1.51E-11	1.00
	PFS (e2)	2.050	2.010	1.610	1.500	1.220	1.270	1.350	1.480	5.95E-13	0.00	1.44E-11	0.00	1.88E-06	0.15	2.69E-06	0.16
	S (e-1)	4.694	6.648	12.563	11.678	9.114	10.580	12.796	12.923	1.51E-11	1.00	1.51E-11	1.00	6.12E-02	0.62	1.00E-04	0.78
20.5	HV (e-2)	4.796	10.541	21.780	22.933	20.123	21.445	24.821	25.483	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	363.855	363.855	168.057	151.357	54.600	54.600	9.300	29.863	1.49E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	IGD (e-3)	4.160	1.903	1.516	1.500	3.222	2.886	1.454	1.455	1.51E-11	1.00	1.89E-04	0.77	1.51E-11	1.00	1.51E-11	1.00
	PFS (e2)	2.010	1.950	1.400	1.460	1.220	1.380	1.340	1.460	6.03E-13	0.00	1.47E-11	0.00	6.70E-03	0.31	9.12E-03	0.32
	S (e-1)	4.526	6.647	11.888	11.907	9.905	9.493	12.763	12.309	1.51E-11	1.00	1.51E-11	1.00	2.54E-03	0.71	1.38E-03	0.73
20.1	HV (e-2)	4.608	16.213	21.659	23.038	19.985	22.941	24.568	25.155	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	35.544	18.072	16.166	14.024	6.290	4.550	1.050	4.381	1.45E-11	1.00	1.51E-11	1.00	1.50E-11	1.00	1.51E-11	1.00
	IGD (e-3)	3.746	1.371	1.185	1.161	2.795	1.666	1.136	1.137	1.51E-11	1.00	1.12E-02	0.67	1.51E-11	1.00	1.51E-11	1.00
	PFS (e2)	2.140	2.060	1.380	1.580	1.240	1.330	1.350	1.470	5.95E-13	0.00	1.44E-11	0.00	5.23E-05	0.21	3.37E-02	0.36
	S (e-1)	4.475	6.468	12.469	11.510	8.939	9.239	12.462	12.653	1.51E-11	1.00	1.51E-11	1.00	2.63E-04	0.76	1.01E-07	0.89

Appendix C. Performance of SATIBEA and eSATIBEA on FreeBSD

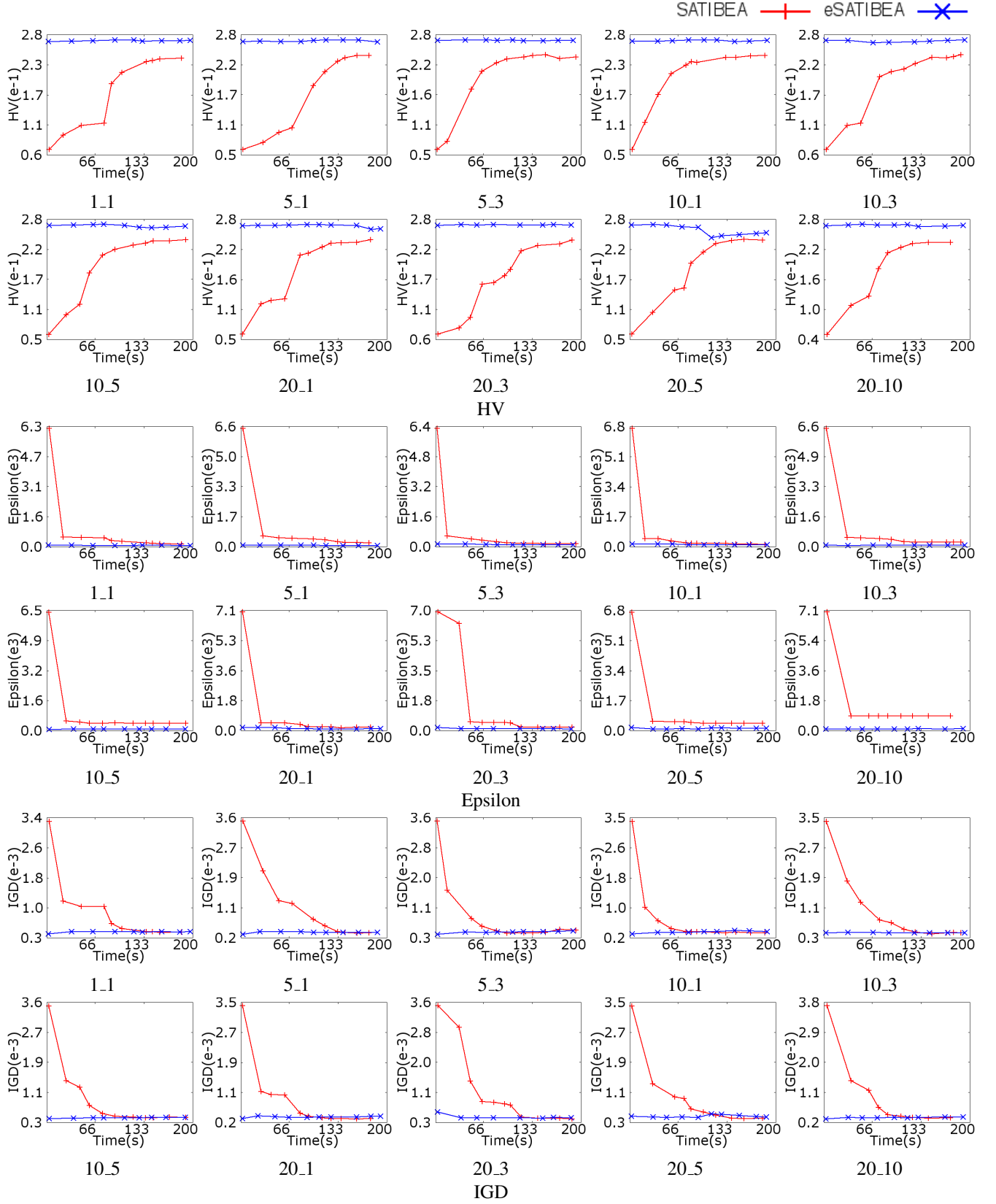


Figure C.5: Evolution of the quality of SATIBEA's and eSATIBEA's solutions for the FreeBSD data set.

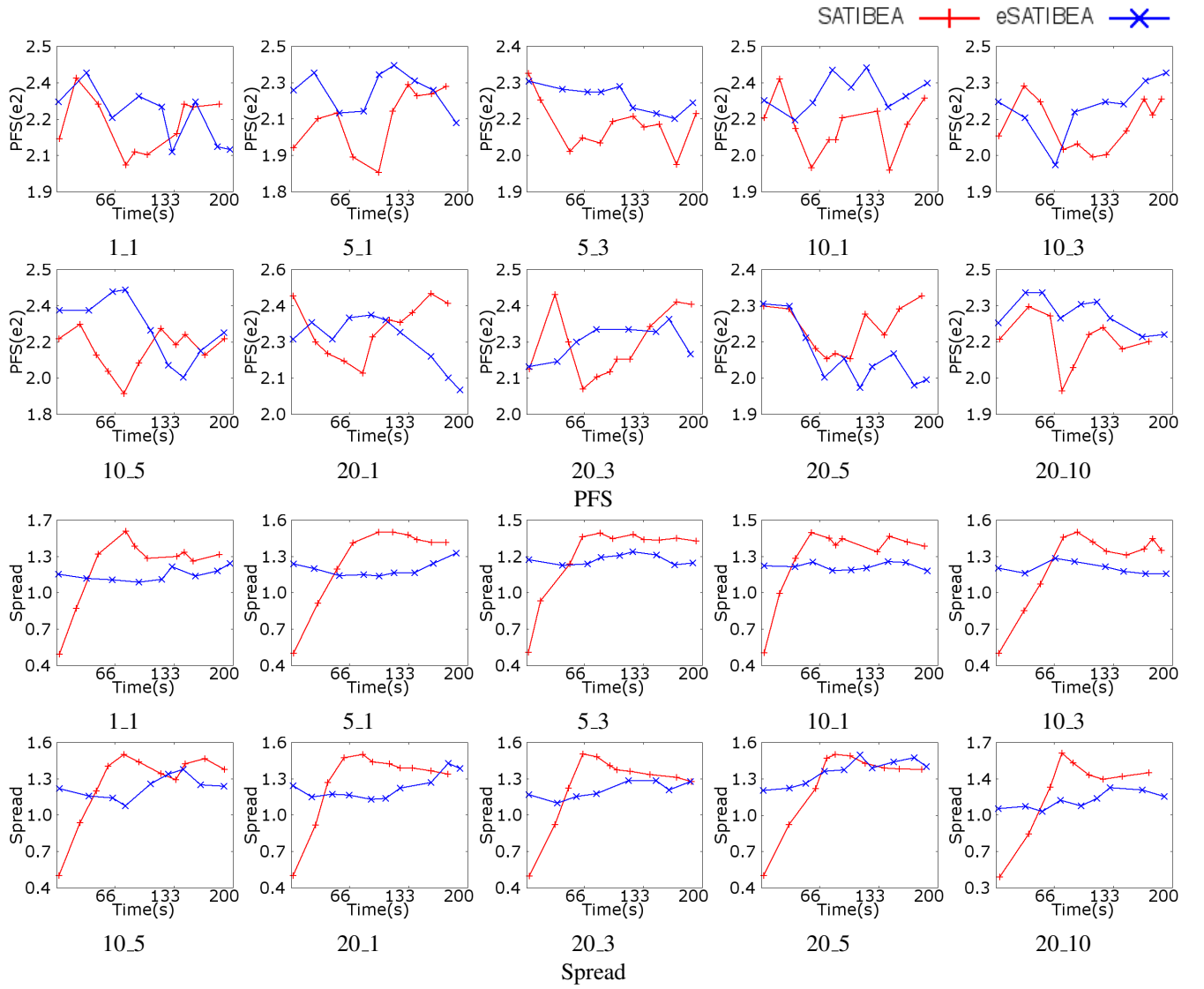


Figure C.6: Evolution of the diversity of SATIBEA and eSATIBEA's solutions for the FreeBSD data set.

Table C.3: Evaluation of the performance of eSATIBEA vs. SATIBEA on the different targets of the FreeBSD data set in four optimisation snapshots(i.e., initial, first, middle and last generations) using five different metrics (i.e., HV, ϵ , IGD, PFS and Spread). We also report the significance of eSATIBEA's results in comparison to those of SATIBEA at each of the four snapshots by means of MWU and \hat{A}_{12} .

Target	Metric	SATIBEA				eSATIBEA				Sig Init		Sig First		Sig Middle		Sig Last	
		Init	First	Middle	Last	Init	First	Middle	Last	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}
1.1	HV (e-2)	6.672	9.433	19.104	23.952	27.111	27.178	27.403	27.289	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	619.183	50.500	33.200	13.400	8.253	8.253	7.000	6.512	6.06E-13	1.00	1.18E-11	1.00	1.48E-11	1.00	1.49E-11	1.00
	IGD (e-4)	32.987	12.250	6.364	4.170	3.650	4.241	4.225	4.231	1.51E-11	1.00	1.51E-11	1.00	3.35E-11	0.99	1.32E-01	0.42
	PFS (e2)	2.140	2.370	2.090	2.270	2.280	2.390	2.260	2.100	1.47E-07	0.89	9.64E-03	0.68	1.04E-09	0.95	4.62E-01	0.51
	S (e-1)	4.661	8.776	14.309	13.549	11.825	11.419	11.353	12.772	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	0.00	2.29E-09	0.06
5.1	HV (e-2)	6.173	7.550	18.390	24.217	26.829	26.936	27.065	26.743	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	650.492	58.800	42.800	22.200	7.700	7.500	7.500	7.400	6.06E-13	1.00	7.79E-12	1.00	1.46E-11	1.00	1.49E-11	1.00
	IGD (e-4)	34.539	20.787	7.425	3.662	3.282	4.019	3.780	3.749	1.51E-11	1.00	1.51E-11	1.00	1.08E-10	0.98	4.09E-01	0.52
	PFS (e2)	1.980	2.130	1.850	2.300	2.280	2.370	2.360	2.110	2.93E-06	0.84	1.24E-01	0.41	4.22E-07	0.87	4.68E-01	0.51
	S (e-1)	4.540	8.721	14.652	13.767	11.998	11.602	10.995	12.894	1.51E-11	1.00	1.51E-11	1.00	1.84E-11	0.00	4.92E-08	0.10
5.3	HV (e-2)	6.085	7.634	23.307	23.664	26.795	26.910	26.868	26.844	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	63.359	5.880	2.160	1.600	1.360	1.360	1.020	1.030	6.06E-13	1.00	1.44E-11	1.00	1.48E-11	1.00	2.23E-11	1.00
	IGD (e-4)	35.499	15.986	3.927	4.758	3.581	4.178	4.229	4.528	1.51E-11	1.00	1.51E-11	1.00	4.96E-11	0.99	2.06E-06	0.15
	PFS (e2)	2.330	2.230	2.150	2.180	2.300	2.270	2.280	2.220	5.89E-06	0.83	4.03E-02	0.63	4.01E-05	0.80	3.75E-01	0.52
	S (e-1)	4.903	8.894	13.686	13.496	12.062	11.641	12.379	11.799	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	0.00	1.08E-03	0.27
10.1	HV (e-2)	6.402	11.602	23.246	24.431	27.148	27.166	27.375	27.306	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	67.343	4.730	2.160	1.540	1.770	1.720	1.340	1.150	6.06E-13	1.00	8.88E-12	1.00	1.50E-11	1.00	3.64E-10	0.96
	IGD (e-4)	33.550	10.505	3.937	3.642	3.306	3.770	3.920	3.951	1.51E-11	1.00	1.51E-11	1.00	1.46E-09	0.95	1.01E-08	0.08
	PFS (e2)	2.220	2.400	2.120	2.310	2.300	2.210	2.360	2.380	7.62E-08	0.89	2.10E-01	0.56	1.04E-08	0.92	6.01E-02	0.62
	S (e-1)	4.869	9.606	13.430	13.369	11.801	11.738	11.453	11.378	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	0.00	5.78E-08	0.10
10.3	HV (e-2)	6.538	11.023	21.499	24.132	26.786	26.738	26.448	26.848	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	645.652	49.600	27.500	25.549	8.700	7.300	7.500	7.500	6.06E-13	1.00	8.76E-12	1.00	1.39E-11	1.00	1.49E-11	1.00
	IGD (e-4)	34.157	18.100	5.137	4.174	4.203	4.253	4.205	4.178	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	6.48E-02	0.39
	PFS (e2)	2.110	2.300	2.030	2.250	2.240	2.180	2.200	2.350	2.58E-10	0.97	3.00E-02	0.36	1.84E-08	0.91	1.04E-01	0.60
	S (e-1)	4.509	8.081	13.850	13.122	11.642	11.210	12.182	11.167	1.51E-11	1.00	1.51E-11	1.00	2.49E-11	0.01	2.10E-10	0.03
10.5	HV (e-2)	6.009	9.781	22.313	24.124	26.908	26.967	26.863	26.732	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	637.198	52.300	41.774	40.305	7.100	8.800	8.800	7.800	6.06E-13	1.00	1.36E-11	1.00	1.48E-11	1.00	1.50E-11	1.00
	IGD (e-4)	34.637	14.376	4.725	4.409	4.019	4.174	4.261	4.364	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	2.11E-03	0.72
	PFS (e2)	2.210	2.280	2.090	2.210	2.350	2.350	2.250	2.240	1.32E-11	1.00	4.94E-01	0.50	1.61E-10	0.97	2.84E-01	0.46
	S (e-1)	4.689	9.013	13.986	13.354	11.776	11.173	12.194	11.993	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	0.00	1.33E-09	0.05
20.1	HV (e-2)	6.027	11.798	21.498	24.066	26.664	26.737	26.898	26.120	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	70.240	4.734	2.450	2.130	1.860	1.860	1.170	1.380	6.06E-13	1.00	1.32E-11	1.00	1.40E-11	1.00	1.05E-10	0.98
	IGD (e-4)	34.060	10.756	4.020	3.330	3.375	4.121	3.694	4.046	1.51E-11	1.00	1.51E-11	1.00	9.25E-09	0.92	7.15E-09	0.07
	PFS (e2)	2.450	2.260	2.280	2.420	2.270	2.340	2.370	2.060	6.62E-03	0.69	3.20E-01	0.46	1.64E-07	0.88	4.73E-01	0.49
	S (e-1)	4.568	8.791	14.049	13.043	12.053	11.132	10.932	13.490	1.51E-11	1.00	1.51E-11	1.00	3.35E-11	0.01	1.78E-04	0.23
20.3	HV (e-2)	6.611	7.756	17.367	23.921	26.687	26.786	26.808	26.745	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	69.473	62.741	4.870	2.224	2.090	1.410	1.380	1.230	6.06E-13	1.00	1.23E-11	1.00	1.49E-11	1.00	1.50E-11	1.00
	IGD (e-4)	35.297	29.330	8.071	3.888	5.781	4.132	4.206	4.146	1.51E-11	1.00	1.51E-11	1.00	2.75E-11	0.99	7.92E-05	0.22
	PFS (e2)	2.150	2.450	2.140	2.410	2.160	2.180	2.310	2.210	3.53E-02	0.64	2.18E-04	0.24	4.03E-05	0.80	4.30E-01	0.51
	S (e-1)	4.757	9.109	14.137	12.793	11.677	10.937	11.730	12.793	1.51E-11	1.00	1.51E-11	1.00	1.74E-10	0.03	8.03E-07	0.14
20.5	HV (e-2)	6.419	10.452	19.645	23.930	26.796	26.843	26.322	25.343	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	670.919	53.100	45.000	40.785	17.700	8.900	7.700	12.500	6.06E-13	1.00	1.38E-11	1.00	1.48E-11	1.00	1.50E-11	1.00
	IGD (e-4)	34.030	13.270	6.599	4.203	4.645	4.425	4.357	4.477	1.51E-11	1.00	1.51E-11	1.00	2.79E-10	0.97	4.39E-02	0.63
	PFS (e2)	2.300	2.290	2.120	2.340	2.310	2.300	2.100	2.020	3.74E-05	0.80	1.48E-01	0.42	2.21E-08	0.91	3.98E-01	0.52
	S (e-1)	4.582	8.820	14.665	13.412	11.681	11.865	13.384	13.658	1.51E-11	1.00	1.51E-11	1.00	2.75E-11	0.01	1.14E-05	0.18
20.1	HV (e-2)	4.635	10.510	21.066	23.184	26.523	26.658	26.671	26.560	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	70.420	8.751	8.657	8.657	1.020	1.030	1.000	1.040	1.18E-12	1.00	6.86E-12	1.00	1.41E-11	1.00	1.49E-11	1.00
	IGD (e-4)	37.169	14.780	4.662	3.730	3.356	3.887	3.899	4.024	1.51E-11	1.00	1.51E-11	1.00	1.67E-11	1.00	5.60E-02	0.62
	PFS (e2)	2.190	2.330	2.070	2.180	2.260	2.390	2.340	2.210	1.15E-02	0.67	6.07E-02	0.62	1.73E-07	0.88	4.88E-01	0.50
	S (e-1)	4.478	8.494	15.080	14.182	10.806	11.018	11.088	11.961	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	0.00	2.73E-06	0.16

Appendix D. Performance of SATIBEA and eSATIBEA on μ Clinux

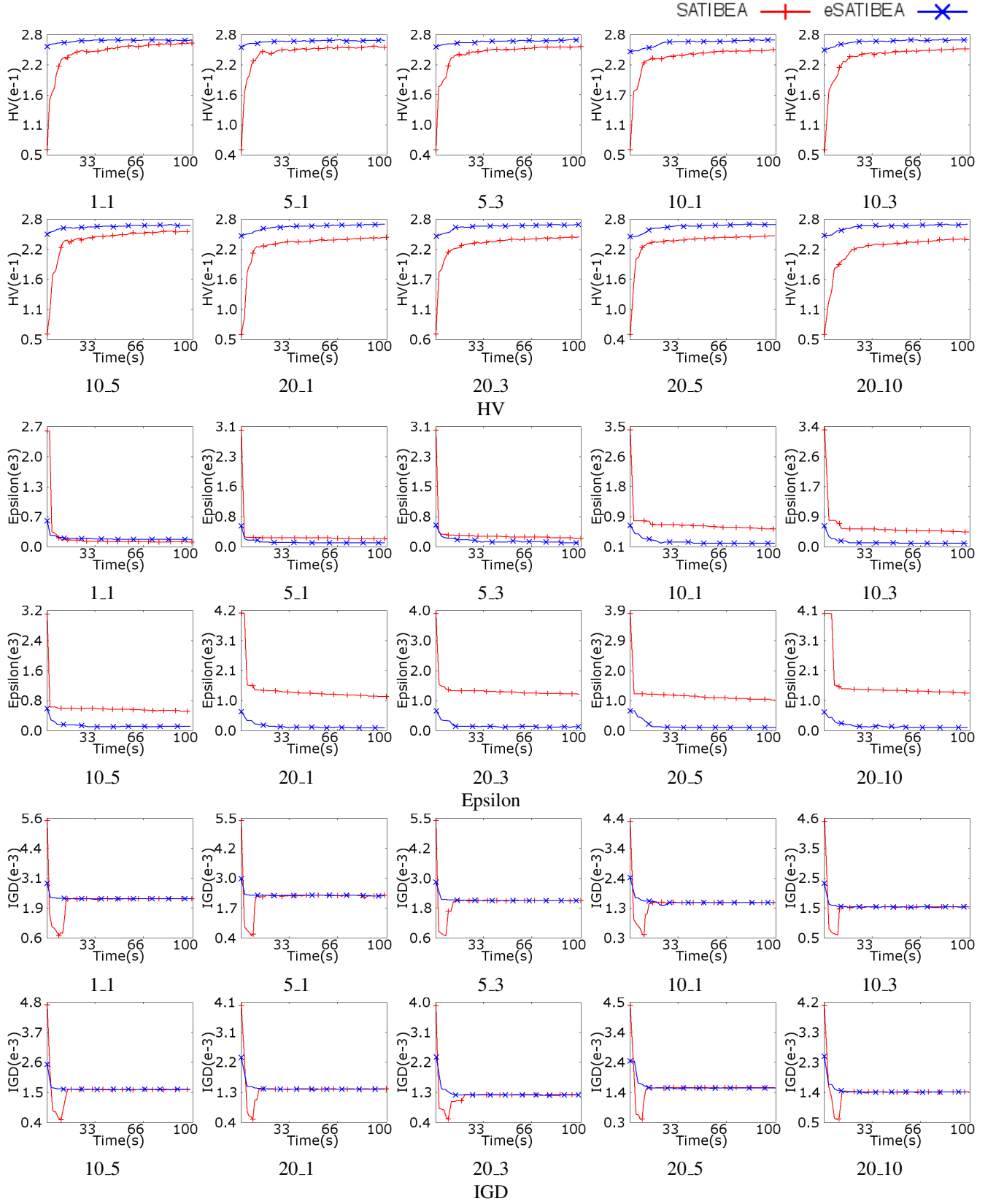


Figure D.7: Evolution of the quality of SATIBEA's and eSATIBEA's solutions for the μ Clinux data set.

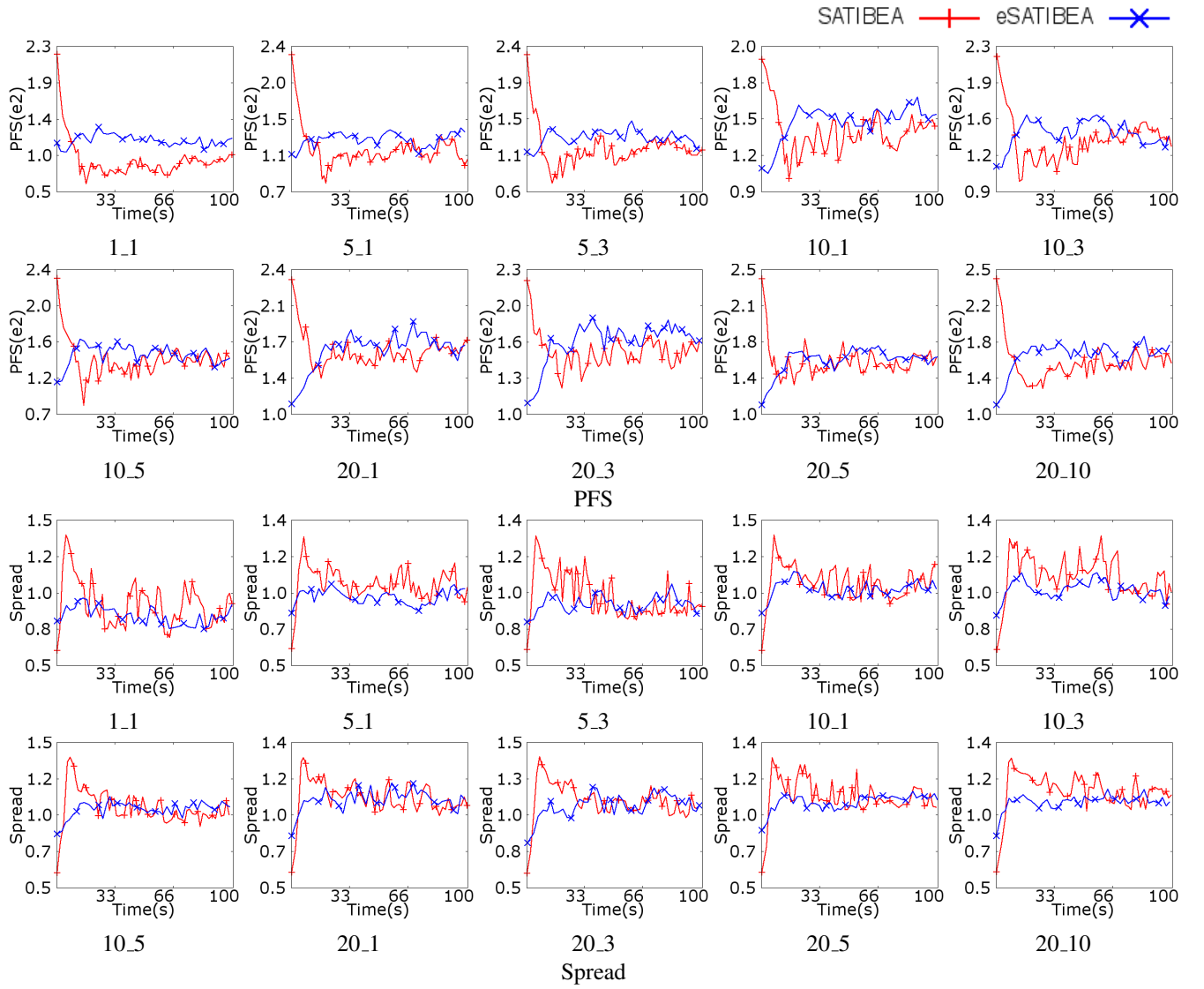


Figure D.8: Evolution of the diversity of SATIBEA and eSATIBEA's solutions for the uClinux data set.

Table D.4: Evaluation of the performance of eSATIBEA vs. SATIBEA on the different targets of the μ CLinux data set in four optimisation snapshots(i.e., initial, first, middle and last generations) using five different metrics (i.e., HV, ϵ , IGD, PFS and Spread). We also report the significance of eSATIBEA's results in comparison to those of SATIBEA at each of the four snapshots by means of MWU and \hat{A}_{12} .

Target	Metric	SATIBEA				eSATIBEA				Sig Init		Sig First		Sig Middle		Sig Last	
		Init	First	Middle	Last	Init	First	Middle	Last	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}	MWU	\hat{A}_{12}
1.1	HV (e-2)	5.857	15.153	25.177	26.067	25.339	25.817	26.559	26.585	6.06E-13	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	25.861	25.861	1.140	1.050	5.830	2.540	1.660	1.660	6.06E-13	1.00	2.35E-04	0.76	9.25E-04	0.27	2.31E-03	0.29
	IGD (e-3)	5.534	1.652	2.251	2.267	2.920	2.312	2.272	2.272	6.06E-13	1.00	5.02E-04	0.25	6.62E-05	0.21	1.14E-05	0.18
	PFS (e1)	22.100	17.700	8.200	9.700	11.100	10.100	11.200	11.700	5.98E-13	0.00	1.43E-11	0.00	2.20E-11	1.00	1.20E-10	0.98
	S (e-1)	6.279	7.707	10.224	9.363	8.208	8.220	7.868	9.294	6.06E-13	1.00	6.56E-09	0.93	2.22E-07	0.12	3.27E-04	0.24
5.1	HV (e-2)	5.339	16.471	25.348	25.558	25.530	25.950	26.801	26.939	6.06E-13	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	29.987	2.810	2.567	2.259	5.650	2.280	1.300	1.290	6.06E-13	1.00	4.32E-05	0.80	3.67E-11	0.99	7.28E-11	0.98
	IGD (e-4)	53.958	9.182	22.422	22.498	29.445	22.778	22.421	22.354	6.06E-13	1.00	5.09E-06	0.17	6.24E-05	0.21	1.00E-06	0.14
	PFS (e2)	2.290	1.910	1.120	1.050	1.110	1.070	1.330	1.380	5.99E-13	0.00	1.47E-11	0.00	2.84E-11	0.99	4.15E-07	0.87
	S (e-1)	6.286	7.969	10.041	9.986	8.442	9.141	9.527	9.896	6.06E-13	1.00	1.51E-11	1.00	1.90E-07	0.12	1.41E-02	0.33
5.3	HV (e-2)	5.171	17.792	25.258	25.761	25.717	26.068	26.891	27.118	6.06E-13	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	299.612	38.030	25.960	22.177	55.600	26.500	15.000	9.700	6.06E-13	1.00	6.39E-07	0.86	1.50E-11	1.00	1.50E-11	1.00
	IGD (e-4)	53.604	8.285	20.727	20.958	28.486	21.437	20.979	20.967	6.06E-13	1.00	1.76E-07	0.12	2.21E-06	0.15	4.90E-05	0.21
	PFS (e2)	2.280	1.870	1.180	1.130	1.110	1.050	1.290	1.160	5.96E-13	0.00	1.47E-11	0.00	1.94E-11	1.00	2.91E-08	0.91
	S (e-1)	6.389	8.178	10.841	9.048	8.098	8.247	8.978	8.634	6.06E-13	1.00	3.85E-08	0.90	4.63E-09	0.07	2.10E-02	0.35
10.1	HV (e-2)	6.157	17.215	24.393	25.143	24.793	24.947	26.766	27.030	6.06E-13	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	33.888	7.929	6.514	5.572	6.600	4.180	1.550	1.510	6.06E-13	1.00	1.51E-11	1.00	1.49E-11	1.00	1.50E-11	1.00
	IGD (e-4)	43.221	9.567	15.401	15.310	23.889	16.965	15.400	15.420	6.06E-13	1.00	3.51E-02	0.36	8.12E-02	0.61	5.09E-06	0.17
	PFS (e2)	1.940	1.860	1.310	1.430	1.110	1.070	1.430	1.520	5.92E-13	0.00	1.47E-11	0.00	7.82E-10	0.95	1.83E-04	0.77
	S (e-1)	6.056	8.500	10.575	11.700	8.494	8.909	9.473	10.106	6.06E-13	1.00	1.51E-11	1.00	2.66E-03	0.29	7.90E-02	0.39
10.3	HV (e-2)	5.793	17.180	24.740	25.199	24.996	25.272	26.768	26.918	6.06E-13	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	33.011	7.737	5.036	4.495	6.290	3.270	1.460	1.430	6.06E-13	1.00	4.04E-11	0.99	1.50E-11	1.00	1.51E-11	1.00
	IGD (e-4)	44.576	7.834	15.195	15.342	23.428	16.287	15.311	15.345	6.06E-13	1.00	3.46E-04	0.24	3.75E-01	0.48	3.65E-04	0.25
	PFS (e2)	2.200	1.930	1.400	1.310	1.110	1.100	1.560	1.410	5.95E-13	0.00	1.47E-11	0.00	3.63E-10	0.96	1.71E-04	0.77
	S (e-1)	6.207	7.927	11.243	9.881	8.387	8.973	10.510	9.576	6.06E-13	1.00	1.67E-11	1.00	4.44E-06	0.17	1.96E-02	0.34
10.5	HV (e-2)	6.137	10.457	24.815	25.484	24.985	25.429	26.505	26.645	6.06E-13	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	31.465	6.492	5.867	5.439	6.080	3.030	1.220	1.320	6.06E-13	1.00	4.93E-11	0.99	1.50E-11	1.00	1.49E-11	1.00
	IGD (e-3)	4.656	2.322	1.603	1.612	2.509	1.678	1.611	1.620	6.06E-13	1.00	5.84E-06	0.17	4.73E-03	0.30	1.19E-08	0.08
	PFS (e2)	2.300	1.930	1.420	1.390	1.110	1.120	1.420	1.380	5.90E-13	0.00	1.46E-11	0.00	3.19E-07	0.87	1.62E-02	0.66
	S (e-1)	5.856	7.930	10.948	9.772	8.476	8.642	10.066	10.285	6.06E-13	1.00	2.04E-11	1.00	1.00E-04	0.22	8.57E-02	0.40
20.1	HV (e-2)	5.518	8.731	23.754	24.503	24.825	25.198	26.740	27.031	6.06E-13	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e1)	405.062	404.017	129.120	117.413	65.800	34.300	11.400	9.200	6.06E-13	1.00	1.51E-11	1.00	1.50E-11	1.00	1.50E-11	1.00
	IGD (e-3)	3.973	2.348	1.399	1.393	2.362	1.475	1.353	1.388	6.06E-13	1.00	1.69E-02	0.34	1.52E-03	0.72	1.78E-01	0.57
	PFS (e2)	2.320	2.150	1.480	1.730	1.110	1.190	1.650	1.680	6.00E-13	0.00	1.46E-11	0.00	1.36E-07	0.89	4.57E-02	0.63
	S (e-1)	5.995	7.497	9.914	10.346	8.375	9.739	10.552	10.724	6.06E-13	1.00	1.67E-11	1.00	2.49E-04	0.24	2.23E-01	0.44
20.3	HV (e-2)	6.556	18.183	24.255	24.764	24.916	25.295	26.879	27.068	6.06E-13	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	39.081	15.467	12.899	12.159	6.560	3.550	1.390	1.330	6.06E-13	1.00	1.51E-11	1.00	1.50E-11	1.00	1.49E-11	1.00
	IGD (e-4)	39.292	8.208	12.259	12.357	23.763	14.134	12.283	12.255	6.06E-13	1.00	4.81E-02	0.37	3.26E-08	0.91	3.05E-03	0.71
	PFS (e2)	2.190	2.050	1.700	1.670	1.110	1.150	1.770	1.660	6.00E-13	0.00	1.47E-11	0.00	1.08E-08	0.92	5.26E-02	0.62
	S (e-1)	6.095	7.666	11.242	10.801	8.163	8.809	11.451	10.761	6.06E-13	1.00	2.75E-11	0.99	1.39E-05	0.18	2.02E-01	0.56
20.5	HV (e-2)	4.813	16.001	24.602	25.086	24.911	24.912	27.172	27.393	6.06E-13	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	38.144	11.976	10.924	9.990	6.490	6.480	1.060	1.010	6.06E-13	1.00	1.51E-11	1.00	1.51E-11	1.00	1.49E-11	1.00
	IGD (e-3)	4.362	1.948	1.523	1.524	2.439	2.434	1.515	1.521	6.06E-13	1.00	3.38E-05	0.20	5.20E-05	0.79	9.56E-03	0.68
	PFS (e2)	2.430	2.060	1.620	1.600	1.110	1.230	1.730	1.610	5.98E-13	0.00	1.46E-11	0.00	6.12E-08	0.90	8.09E-03	0.68
	S (e-1)	5.922	7.572	9.912	10.086	8.597	9.058	10.153	10.552	6.06E-13	1.00	1.51E-11	1.00	1.11E-01	0.41	1.29E-01	0.59
20.1	HV (e-2)	5.708	11.964	23.515	24.146	25.032	25.038	26.912	27.163	6.06E-13	1.00	1.51E-11	1.00	1.51E-11	1.00	1.51E-11	1.00
	ϵ (e2)	40.490	40.394	13.835	12.951	6.520	4.670	1.160	1.130	6.06E-13	1.00	1.51E-11	1.00	1.50E-11	1.00	1.50E-11	1.00
	IGD (e-3)	4.098	1.607	1.400	1.412	2.512	1.632	1.400	1.405	6.06E-13	1.00	4.34E-03	0.30	2.34E-08	0.91	2.66E-03	0.71
	PFS (e2)	2.440	2.180	1.580	1.550	1.110	1.180	1.690	1.740	6.00E-13	0.00	1.46E-11	0.00	2.45E-10	0.97	1.63E-05	0.81
	S (e-1)	6.118	7.915	11.529	11.011	8.438	9.816	10.226	10.556	6.06E-13	1.00	1.51E-11	1.00	1.17E-01	0.41	2.80E-01	0.54