In [161…
```
import sys
sys.path.append("/scratch/group/csce435-f23/python-3.8.17/lib/python3.8/site-packages"
sys.path.append("/scratch/group/csce435-f23/thicket")
from glob import glob

import matplotlib.pyplot as plt
import pandas as pd

import thicket as th

pd.set_option("display.max_rows", None)
pd.set_option("display.max_columns", None)
```

Strong scaling

(same problem size, increase number of processors/nodes)

2^16

In [165…
```
tk16 = th.Thicket.from_caliperreader(glob("cali_data_missingLast2ArraySizes/*65536*.ca
```

In [166…
```
tk16.dataframe
```

Out[166]:

node	profile	nid	spot.channel	Min time/rank	Max time/rank	Avg time/rank	Total time	Vari time/
{'name': 'main', 'type': 'function'}	174450324	1	regionprofile	0.119085	2.036546	0.241097	3.857549	0.21
	213691697	1	regionprofile	0.477346	2.400909	0.961521	3.846084	0.69
	476717927	1	regionprofile	0.956028	3.055820	2.005924	4.011848	1.10
	479751880	1	regionprofile	0.955188	3.163629	2.059409	4.118817	1.21
	499859213	1	regionprofile	0.957421	3.136599	2.047010	4.094021	1.18
	518663421	1	regionprofile	0.238474	2.139834	0.479038	3.832300	0.39
	638224690	1	regionprofile	0.953105	3.151189	2.052147	4.104293	1.20
	1276976617	1	regionprofile	0.237348	2.171399	0.483342	3.866732	0.40
	1545993883	1	regionprofile	0.119359	2.041714	0.241637	3.866200	0.21
	1561571627	1	regionprofile	0.061672	1.964514	0.122418	3.917381	0.10
	1571305564	1	regionprofile	0.120387	2.045904	0.243121	3.889938	0.21
	1723630933	1	regionprofile	0.237736	2.167336	0.482906	3.863248	0.40
	2297290023	1	regionprofile	0.119629	2.045186	0.241968	3.871491	0.21
	2330052012	1	regionprofile	0.060072	1.970814	0.120885	3.868323	0.11
	3058622429	1	regionprofile	0.237935	2.159244	0.480589	3.844709	0.40
	3144206112	1	regionprofile	0.474828	2.379575	0.954506	3.818025	0.67
	3676548621	1	regionprofile	0.478769	2.455001	0.986540	3.946159	0.71
	3925651291	1	regionprofile	0.060091	2.004419	0.121828	3.898505	0.11
	4082794988	1	regionprofile	0.483455	2.421031	0.977502	3.910009	0.69
	4090503034	1	regionprofile	0.060737	1.971719	0.121383	3.884258	0.11
{'name': 'comm', 'type': 'function'}	174450324	3	regionprofile	0.000401	0.015517	0.001784	0.028548	0.00
	213691697	3	regionprofile	0.001277	0.004308	0.002053	0.008213	0.00
	476717927	3	regionprofile	0.000530	0.000664	0.000597	0.001193	0.00
	479751880	3	regionprofile	0.003445	0.004683	0.004064	0.008128	0.00
	499859213	3	regionprofile	0.000538	0.001852	0.001195	0.002390	0.00
	518663421	3	regionprofile	0.000359	0.005412	0.001994	0.015950	0.00
	638224690	3	regionprofile	0.000851	0.001417	0.001134	0.002269	0.00
	1276976617	3	regionprofile	0.000503	0.017599	0.002697	0.021573	0.00
	1545993883	3	regionprofile	0.000277	0.014645	0.001566	0.025054	0.00
	1561571627	3	regionprofile	0.001124	0.007623	0.001429	0.045725	0.00
	1571305564	3	regionprofile	0.000502	0.017597	0.001593	0.025495	0.00
	1723630933	3	regionprofile	0.000340	0.004091	0.002648	0.021188	0.00

node	profile	nid	spot.channel	Min time/rank	Max time/rank	Avg time/rank	Total time	Vari time/
	2297290023	3	regionprofile	0.000448	0.014366	0.001464	0.023423	0.00
	2330052012	3	regionprofile	0.000462	0.007244	0.000872	0.027904	0.00
	3058622429	3	regionprofile	0.000282	0.006800	0.001370	0.010958	0.00
	3144206112	3	regionprofile	0.000380	0.002172	0.001128	0.004513	0.00
	3676548621	3	regionprofile	0.002050	0.048312	0.013838	0.055354	0.00
	3925651291	3	regionprofile	0.000602	0.006345	0.000903	0.028907	0.00
	4082794988	3	regionprofile	0.002547	0.046112	0.013747	0.054987	0.00
	4090503034	3	regionprofile	0.001046	0.005946	0.001342	0.042938	0.00
{'name': 'comm_large', 'type': 'function'}	**174450324**	4	regionprofile	0.000380	0.015497	0.001765	0.028239	0.00
	213691697	4	regionprofile	0.001258	0.004286	0.002032	0.008129	0.00
	476717927	4	regionprofile	0.000509	0.000644	0.000577	0.001153	0.00
	479751880	4	regionprofile	0.003421	0.004654	0.004038	0.008075	0.00
	499859213	4	regionprofile	0.000518	0.001832	0.001175	0.002350	0.00
	518663421	4	regionprofile	0.000339	0.005393	0.001974	0.015795	0.00
	638224690	4	regionprofile	0.000831	0.001395	0.001113	0.002225	0.00
	1276976617	4	regionprofile	0.000483	0.017580	0.002677	0.021420	0.00
	1545993883	4	regionprofile	0.000258	0.014625	0.001547	0.024745	0.00
	1561571627	4	regionprofile	0.001100	0.007603	0.001409	0.045102	0.00
	1571305564	4	regionprofile	0.000484	0.017577	0.001574	0.025189	0.00
	1723630933	4	regionprofile	0.000320	0.004072	0.002629	0.021034	0.00
	2297290023	4	regionprofile	0.000429	0.014346	0.001445	0.023117	0.00
	2330052012	4	regionprofile	0.000442	0.007224	0.000853	0.027286	0.00
	3058622429	4	regionprofile	0.000263	0.006781	0.001351	0.010805	0.00
	3144206112	4	regionprofile	0.000362	0.002153	0.001109	0.004437	0.00
	3676548621	4	regionprofile	0.002028	0.048291	0.013818	0.055271	0.00
	3925651291	4	regionprofile	0.000580	0.006324	0.000884	0.028286	0.00
	4082794988	4	regionprofile	0.002526	0.046091	0.013726	0.054906	0.00
	4090503034	4	regionprofile	0.001028	0.005926	0.001322	0.042298	0.00
{'name': 'MPI_Gather', 'type': 'function'}	**174450324**	9	regionprofile	0.000019	0.014569	0.000936	0.014971	0.00
	213691697	9	regionprofile	0.000028	0.003015	0.000779	0.003115	0.00
	476717927	9	regionprofile	0.000084	0.000092	0.000088	0.000177	0.00
	479751880	9	regionprofile	0.000058	0.000114	0.000086	0.000173	0.00

node	profile	nid	spot.channel	Min time/rank	Max time/rank	Avg time/rank	Total time	Vari time/
	499859213	9	regionprofile	0.000045	0.000112	0.000079	0.000158	0.00
	518663421	9	regionprofile	0.000022	0.003578	0.000474	0.003790	0.00
	638224690	9	regionprofile	0.000085	0.000500	0.000292	0.000585	0.00
	1276976617	9	regionprofile	0.000023	0.017091	0.002168	0.017346	0.00
	1545993883	9	regionprofile	0.000019	0.013860	0.000891	0.014260	0.00
	1561571627	9	regionprofile	0.000019	0.006476	0.000226	0.007218	0.00
	1571305564	9	regionprofile	0.000023	0.017081	0.001095	0.017524	0.00
	1723630933	9	regionprofile	0.000022	0.001435	0.000206	0.001652	0.00
	2297290023	9	regionprofile	0.000020	0.013798	0.000888	0.014204	0.00
	2330052012	9	regionprofile	0.000019	0.006537	0.000228	0.007282	0.00
	3058622429	9	regionprofile	0.000021	0.006060	0.000784	0.006275	0.00
	3144206112	9	regionprofile	0.000026	0.001248	0.000335	0.001341	0.00
	3676548621	9	regionprofile	0.000028	0.046281	0.011810	0.047242	0.00
	3925651291	9	regionprofile	0.000019	0.005618	0.000199	0.006365	0.00
	4082794988	9	regionprofile	0.000025	0.042976	0.010766	0.043065	0.00
	4090503034	9	regionprofile	0.000019	0.004927	0.000178	0.005693	0.00
{'name': 'MPI_Scatter', 'type': 'function'}	**174450324**	5	regionprofile	0.000059	0.000250	0.000154	0.002460	0.00
	213691697	5	regionprofile	0.000110	0.000182	0.000141	0.000564	0.00
	476717927	5	regionprofile	0.000164	0.000313	0.000239	0.000478	0.00
	479751880	5	regionprofile	0.000238	0.001544	0.000891	0.001782	0.00
	499859213	5	regionprofile	0.000207	0.001600	0.000903	0.001806	0.00
	518663421	5	regionprofile	0.000075	0.000306	0.000186	0.001492	0.00
	638224690	5	regionprofile	0.000096	0.000175	0.000136	0.000271	0.00
	1276976617	5	regionprofile	0.000080	0.000326	0.000199	0.001590	0.00
	1545993883	5	regionprofile	0.000061	0.000218	0.000124	0.001983	0.00
	1561571627	5	regionprofile	0.000072	0.000794	0.000350	0.011195	0.00
	1571305564	5	regionprofile	0.000076	0.000264	0.000172	0.002749	0.00
	1723630933	5	regionprofile	0.000073	0.000411	0.000244	0.001952	0.00
	2297290023	5	regionprofile	0.000062	0.000267	0.000169	0.002705	0.00
	2330052012	5	regionprofile	0.000058	0.000257	0.000141	0.004519	0.00
	3058622429	5	regionprofile	0.000068	0.000232	0.000125	0.000999	0.00
	3144206112	5	regionprofile	0.000094	0.000187	0.000143	0.000572	0.00

node	profile	nid	spot.channel	Min time/rank	Max time/rank	Avg time/rank	Total time	Vari time/
	3676548621	5	regionprofile	0.000608	0.001024	0.000734	0.002934	0.00
	3925651291	5	regionprofile	0.000061	0.000220	0.000139	0.004439	0.00
	4082794988	5	regionprofile	0.001076	0.001708	0.001525	0.006100	0.00
	4090503034	5	regionprofile	0.000079	0.000731	0.000402	0.012869	0.00
{'name': 'comp', 'type': 'function'}	**174450324**	6	regionprofile	0.090177	1.548668	0.183112	2.929796	0.12
	213691697	6	regionprofile	0.364217	1.836416	0.734743	2.938971	0.40
	476717927	6	regionprofile	0.732207	2.338937	1.535572	3.071144	0.64
	479751880	6	regionprofile	0.729283	2.425826	1.577555	3.155109	0.71
	499859213	6	regionprofile	0.731010	2.397591	1.564301	3.128602	0.69
	518663421	6	regionprofile	0.180513	1.634464	0.364472	2.915775	0.23
	638224690	6	regionprofile	0.729231	2.409464	1.569347	3.138695	0.70
	1276976617	6	regionprofile	0.180984	1.650152	0.367912	2.943297	0.23
	1545993883	6	regionprofile	0.090584	1.556675	0.183911	2.942575	0.12
	1561571627	6	regionprofile	0.045204	1.497035	0.091445	2.926227	0.06
	1571305564	6	regionprofile	0.090700	1.554432	0.183989	2.943819	0.12
	1723630933	6	regionprofile	0.181949	1.658115	0.368038	2.944304	0.23
	2297290023	6	regionprofile	0.090839	1.555371	0.183950	2.943194	0.12
	2330052012	6	regionprofile	0.045228	1.508561	0.091805	2.937773	0.06
	3058622429	6	regionprofile	0.181212	1.650896	0.367257	2.938058	0.23
	3144206112	6	regionprofile	0.364581	1.826804	0.731976	2.927904	0.39
	3676548621	6	regionprofile	0.363800	1.842296	0.744642	2.978569	0.40
	3925651291	6	regionprofile	0.045281	1.529405	0.092350	2.955194	0.06
	4082794988	6	regionprofile	0.368093	1.820656	0.738723	2.954893	0.39
	4090503034	6	regionprofile	0.045329	1.505154	0.091695	2.934246	0.06
{'name': 'comp_large', 'type': 'function'}	**174450324**	7	regionprofile	0.015862	0.272711	0.032218	0.515496	0.00
	213691697	7	regionprofile	0.065222	0.327193	0.130919	0.523675	0.01
	476717927	7	regionprofile	0.129301	0.409792	0.269547	0.539093	0.01
	479751880	7	regionprofile	0.128735	0.427697	0.278216	0.556432	0.02
	499859213	7	regionprofile	0.127974	0.419144	0.273559	0.547117	0.02
	518663421	7	regionprofile	0.032207	0.290121	0.064885	0.519082	0.00
	638224690	7	regionprofile	0.130827	0.425393	0.278110	0.556220	0.02
	1276976617	7	regionprofile	0.031706	0.292290	0.064983	0.519860	0.00

node	profile	nid	spot.channel	Min time/rank	Max time/rank	Avg time/rank	Total time	Vari time/
	1545993883	7	regionprofile	0.015854	0.274428	0.032319	0.517110	0.00
	1561571627	7	regionprofile	0.008052	0.264322	0.016197	0.518302	0.00
	1571305564	7	regionprofile	0.016063	0.275347	0.032673	0.522770	0.00
	1723630933	7	regionprofile	0.031953	0.293342	0.064814	0.518509	0.00
	2297290023	7	regionprofile	0.015770	0.273868	0.032327	0.517227	0.00
	2330052012	7	regionprofile	0.007937	0.265193	0.016141	0.516498	0.00
	3058622429	7	regionprofile	0.031894	0.289812	0.064475	0.515801	0.00
	3144206112	7	regionprofile	0.064096	0.320929	0.128653	0.514611	0.01
	3676548621	7	regionprofile	0.063669	0.325902	0.131146	0.524586	0.01
	3925651291	7	regionprofile	0.007908	0.266655	0.016137	0.516383	0.00
	4082794988	7	regionprofile	0.064877	0.321206	0.130207	0.520828	0.01
	4090503034	7	regionprofile	0.007928	0.264508	0.016105	0.515375	0.00
{'name': 'comp_small', 'type': 'function'}	**174450324**	8	regionprofile	0.015526	0.268391	0.031717	0.507471	0.00
	213691697	8	regionprofile	0.063031	0.321165	0.127916	0.511666	0.01
	476717927	8	regionprofile	0.126837	0.404274	0.265555	0.531110	0.01
	479751880	8	regionprofile	0.127596	0.423440	0.275518	0.551035	0.02
	499859213	8	regionprofile	0.126740	0.414466	0.270603	0.541206	0.02
	518663421	8	regionprofile	0.031088	0.283799	0.063125	0.504996	0.00
	638224690	8	regionprofile	0.126509	0.417052	0.271780	0.543560	0.02
	1276976617	8	regionprofile	0.031139	0.288829	0.064104	0.512833	0.00
	1545993883	8	regionprofile	0.015735	0.272048	0.032028	0.512455	0.00
	1561571627	8	regionprofile	0.007803	0.258510	0.015793	0.505381	0.00
	1571305564	8	regionprofile	0.015463	0.269645	0.031799	0.508789	0.00
	1723630933	8	regionprofile	0.031609	0.290698	0.064217	0.513740	0.00
	2297290023	8	regionprofile	0.015593	0.270480	0.031987	0.511787	0.00
	2330052012	8	regionprofile	0.007832	0.262857	0.015952	0.510459	0.00
	3058622429	8	regionprofile	0.031530	0.287325	0.063953	0.511623	0.00
	3144206112	8	regionprofile	0.063400	0.317274	0.127313	0.509253	0.01
	3676548621	8	regionprofile	0.063040	0.322643	0.129896	0.519582	0.01
	3925651291	8	regionprofile	0.007810	0.263887	0.015978	0.511280	0.00
	4082794988	8	regionprofile	0.063727	0.315490	0.127941	0.511762	0.01
	4090503034	8	regionprofile	0.007844	0.260217	0.015863	0.507616	0.00

node	profile	nid	spot.channel	Min time/rank	Max time/rank	Avg time/rank	Total time	Vari time/
{'name': 'correctness_check', 'type': 'function'}	174450324	10	regionprofile	0.000190	0.000190	0.000190	0.000190	0.00
	213691697	10	regionprofile	0.000190	0.000190	0.000190	0.000190	0.00
	476717927	10	regionprofile	0.000201	0.000201	0.000201	0.000201	0.00
	479751880	10	regionprofile	0.000200	0.000200	0.000200	0.000200	0.00
	499859213	10	regionprofile	0.000198	0.000198	0.000198	0.000198	0.00
	518663421	10	regionprofile	0.000189	0.000189	0.000189	0.000189	0.00
	638224690	10	regionprofile	0.000194	0.000194	0.000194	0.000194	0.00
	1276976617	10	regionprofile	0.000194	0.000194	0.000194	0.000194	0.00
	1545993883	10	regionprofile	0.000189	0.000189	0.000189	0.000189	0.00
	1561571627	10	regionprofile	0.000210	0.000210	0.000210	0.000210	0.00
	1571305564	10	regionprofile	0.000194	0.000194	0.000194	0.000194	0.00
	1723630933	10	regionprofile	0.000194	0.000194	0.000194	0.000194	0.00
	2297290023	10	regionprofile	0.000194	0.000194	0.000194	0.000194	0.00
	2330052012	10	regionprofile	0.000199	0.000199	0.000199	0.000199	0.00
	3058622429	10	regionprofile	0.000189	0.000189	0.000189	0.000189	0.00
	3144206112	10	regionprofile	0.000190	0.000190	0.000190	0.000190	0.00
	3676548621	10	regionprofile	0.000193	0.000193	0.000193	0.000193	0.00
	3925651291	10	regionprofile	0.000192	0.000192	0.000192	0.000192	0.00
	4082794988	10	regionprofile	0.000190	0.000190	0.000190	0.000190	0.00
	4090503034	10	regionprofile	0.000198	0.000198	0.000198	0.000198	0.00
{'name': 'data_init', 'type': 'function'}	174450324	2	regionprofile	0.000289	0.000305	0.000298	0.004762	0.00
	213691697	2	regionprofile	0.001589	0.001628	0.001600	0.006401	0.00
	476717927	2	regionprofile	0.000294	0.000298	0.000296	0.000592	0.00
	479751880	2	regionprofile	0.000266	0.000267	0.000266	0.000533	0.00
	499859213	2	regionprofile	0.000350	0.000359	0.000355	0.000710	0.00
	518663421	2	regionprofile	0.001581	0.001597	0.001590	0.012719	0.00
	638224690	2	regionprofile	0.001584	0.001585	0.001585	0.003169	0.00
	1276976617	2	regionprofile	0.000288	0.000309	0.000295	0.002358	0.00
	1545993883	2	regionprofile	0.000264	0.000283	0.000273	0.004364	0.00
	1561571627	2	regionprofile	0.001584	0.001595	0.001590	0.050873	0.00
	1571305564	2	regionprofile	0.001601	0.001618	0.001609	0.025744	0.00
	1723630933	2	regionprofile	0.000258	0.000269	0.000265	0.002119	0.00

node	profile	nid	spot.channel	Min time/rank	Max time/rank	Avg time/rank	Total time	Vari time/
	2297290023	2	regionprofile	0.000355	0.000368	0.000362	0.005794	0.00
	2330052012	2	regionprofile	0.000349	0.000380	0.000356	0.011408	0.00
	3058622429	2	regionprofile	0.000349	0.000369	0.000358	0.002861	0.00
	3144206112	2	regionprofile	0.000262	0.000274	0.000266	0.001063	0.00
	3676548621	2	regionprofile	0.000350	0.000356	0.000353	0.001411	0.00
	3925651291	2	regionprofile	0.000267	0.000325	0.000300	0.009612	0.00
	4082794988	2	regionprofile	0.000291	0.000295	0.000293	0.001173	0.00
	4090503034	2	regionprofile	0.000291	0.000321	0.000302	0.009675	0.00

In [167…

```
tk16.metadata
```

Out[167]:

profile	cali.caliper.version	mpi.world.size	spot.metrics	spot.tir
174450324	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
213691697	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
476717927	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
479751880	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
499859213	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
518663421	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
638224690	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
1276976617	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
1545993883	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
1561571627	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
1571305564	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
1723630933	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
2297290023	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
2330052012	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
3058622429	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
3144206112	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
3676548621	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
3925651291	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
4082794988	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
4090503034	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	

In [168…
```
tk16.statsframe.dataframe["time"] = 1
print(tk16.tree())
```

```
  _____ _     _      _        _
 |_   _| |__ (_) ___| | _____| |_
   | | | '_ \| |/ __| |/ / _ \ __|
   | | | | | | | (__|   <  __/ |_
   |_| |_| |_|_|\___|_|\_\___|\__|  v2023.3.0

1.000 main
├─ 1.000 comm
│  └─ 1.000 comm_large
│     ├─ 1.000 MPI_Gather
│     └─ 1.000 MPI_Scatter
├─ 1.000 comp
│  ├─ 1.000 comp_large
│  └─ 1.000 comp_small
├─ 1.000 correctness_check
└─ 1.000 data_init

Legend (Metric: time Min: 1.00 Max: 1.00)
 1.00 - 1.00
 1.00 - 1.00
 1.00 - 1.00
 1.00 - 1.00
 1.00 - 1.00
 1.00 - 1.00

name User code    ◀ Only in left graph    ▶ Only in right graph
```

In [169…
```
gb16 = tk16.groupby("InputType")
```

```
4  thickets created...
{'1% Perturbed': <thicket.thicket.Thicket object at 0x2b2706cb1a30>, 'Random': <thick
et.thicket.Thicket object at 0x2b27053a2790>, 'Reverse Sorted': <thicket.thicket.Thic
ket object at 0x2b2705231dc0>, 'Sorted': <thicket.thicket.Thicket object at 0x2b27052
8cee0>}
```

In [170…
```
ctk16 = th.Thicket.concat_thickets(
    thickets=list(gb16.values()),
    headers=list(gb16.keys()),
    axis='columns',
    metadata_key='num_procs'
)
```

In [171…
```
ctk16.dataframe
```

Out[171]:

1% Perturb

node	num_procs	nid	spot.channel	Min time/rank	Max time/rank	Avg time/rank	Total time	Variar time/ra
{'name': 'main', 'type': 'function'}	2	1	regionprofile	0.956028	3.055820	2.005924	4.011848	1.102
	4	1	regionprofile	0.483455	2.421031	0.977502	3.910009	0.694
	8	1	regionprofile	0.237348	2.171399	0.483342	3.866732	0.407
	16	1	regionprofile	0.119085	2.036546	0.241097	3.857549	0.214
	32	1	regionprofile	0.060737	1.971719	0.121383	3.884258	0.110
{'name': 'comm', 'type': 'function'}	2	3	regionprofile	0.000530	0.000664	0.000597	0.001193	0.000
	4	3	regionprofile	0.002547	0.046112	0.013747	0.054987	0.000
	8	3	regionprofile	0.000503	0.017599	0.002697	0.021573	0.000
	16	3	regionprofile	0.000401	0.015517	0.001784	0.028548	0.000
	32	3	regionprofile	0.001046	0.005946	0.001342	0.042938	0.000
{'name': 'comm_large', 'type': 'function'}	2	4	regionprofile	0.000509	0.000644	0.000577	0.001153	0.000
	4	4	regionprofile	0.002526	0.046091	0.013726	0.054906	0.000
	8	4	regionprofile	0.000483	0.017580	0.002677	0.021420	0.000
	16	4	regionprofile	0.000380	0.015497	0.001765	0.028239	0.000
	32	4	regionprofile	0.001028	0.005926	0.001322	0.042298	0.000
{'name': 'MPI_Gather', 'type': 'function'}	2	9	regionprofile	0.000084	0.000092	0.000088	0.000177	0.000
	4	9	regionprofile	0.000025	0.042976	0.010766	0.043065	0.000
	8	9	regionprofile	0.000023	0.017091	0.002168	0.017346	0.000
	16	9	regionprofile	0.000019	0.014569	0.000936	0.014971	0.000
	32	9	regionprofile	0.000019	0.004927	0.000178	0.005693	0.000
{'name': 'MPI_Scatter', 'type': 'function'}	2	5	regionprofile	0.000164	0.000313	0.000239	0.000478	0.000
	4	5	regionprofile	0.001076	0.001708	0.001525	0.006100	0.000
	8	5	regionprofile	0.000080	0.000326	0.000199	0.001590	0.000
	16	5	regionprofile	0.000059	0.000250	0.000154	0.002460	0.000
	32	5	regionprofile	0.000079	0.000731	0.000402	0.012869	0.000
{'name': 'comp', 'type': 'function'}	2	6	regionprofile	0.732207	2.338937	1.535572	3.071144	0.645
	4	6	regionprofile	0.368093	1.820656	0.738723	2.954893	0.390
	8	6	regionprofile	0.180984	1.650152	0.367912	2.943297	0.234
	16	6	regionprofile	0.090177	1.548668	0.183112	2.929796	0.124
	32	6	regionprofile	0.045329	1.505154	0.091695	2.934246	0.064
{'name': 'comp_large',	2	7	regionprofile	0.129301	0.409792	0.269547	0.539093	0.019

								1% Perturb
		nid	spot.channel	Min time/rank	Max time/rank	Avg time/rank	Total time	Variar time/ra
node	num_procs							
'type': 'function'}	4	7	regionprofile	0.064877	0.321206	0.130207	0.520828	0.012
	8	7	regionprofile	0.031706	0.292290	0.064983	0.519860	0.007
	16	7	regionprofile	0.015862	0.272711	0.032218	0.515496	0.003
	32	7	regionprofile	0.007928	0.264508	0.016105	0.515375	0.001
{'name': 'comp_small', 'type': 'function'}	2	8	regionprofile	0.126837	0.404274	0.265555	0.531110	0.019
	4	8	regionprofile	0.063727	0.315490	0.127941	0.511762	0.011
	8	8	regionprofile	0.031139	0.288829	0.064104	0.512833	0.007
	16	8	regionprofile	0.015526	0.268391	0.031717	0.507471	0.003
	32	8	regionprofile	0.007844	0.260217	0.015863	0.507616	0.001
{'name': 'correctness_check', 'type': 'function'}	2	10	regionprofile	0.000201	0.000201	0.000201	0.000201	0.000
	4	10	regionprofile	0.000190	0.000190	0.000190	0.000190	0.000
	8	10	regionprofile	0.000194	0.000194	0.000194	0.000194	0.000
	16	10	regionprofile	0.000190	0.000190	0.000190	0.000190	0.000
	32	10	regionprofile	0.000198	0.000198	0.000198	0.000198	0.000
{'name': 'data_init', 'type': 'function'}	2	2	regionprofile	0.000294	0.000298	0.000296	0.000592	0.000
	4	2	regionprofile	0.000291	0.000295	0.000293	0.001173	0.000
	8	2	regionprofile	0.000288	0.000309	0.000295	0.002358	0.000
	16	2	regionprofile	0.000289	0.000305	0.000298	0.004762	0.000
	32	2	regionprofile	0.000291	0.000321	0.000302	0.009675	0.000

In [172…

```
ctk16.dataframe = ctk16.dataframe.reset_index().drop([("node", ""), ('1% Perturbed', '
                                                      ('Random', "nid"), ('Random', "s
                                                      ('Reverse Sorted', "nid"), ('Rev
                                                      ('Sorted', "nid"), ('Sorted', "s
                                                     ], axis=1)
```

In [173…

```
ctk16.dataframe = ctk16.dataframe.rename({("name", ""): "name", ("num_procs", ""): "nu
ctk16.dataframe
```

Out[173]:

		1% Perturbed	Random	Reverse Sorted	Sorted
		Avg time/rank	Avg time/rank	Avg time/rank	Avg time/rank
name	num_procs				
main	2	2.005924	2.052147	2.047010	2.059409
	4	0.977502	0.961521	0.986540	0.954506
	8	0.483342	0.479038	0.480589	0.482906
	16	0.241097	0.243121	0.241968	0.241637
	32	0.121383	0.122418	0.120885	0.121828
comm	2	0.000597	0.001134	0.001195	0.004064
	4	0.013747	0.002053	0.013838	0.001128
	8	0.002697	0.001994	0.001370	0.002648
	16	0.001784	0.001593	0.001464	0.001566
	32	0.001342	0.001429	0.000872	0.000903
comm_large	2	0.000577	0.001113	0.001175	0.004038
	4	0.013726	0.002032	0.013818	0.001109
	8	0.002677	0.001974	0.001351	0.002629
	16	0.001765	0.001574	0.001445	0.001547
	32	0.001322	0.001409	0.000853	0.000884
MPI_Gather	2	0.000088	0.000292	0.000079	0.000086
	4	0.010766	0.000779	0.011810	0.000335
	8	0.002168	0.000474	0.000784	0.000206
	16	0.000936	0.001095	0.000888	0.000891
	32	0.000178	0.000226	0.000228	0.000199
MPI_Scatter	2	0.000239	0.000136	0.000903	0.000891
	4	0.001525	0.000141	0.000734	0.000143
	8	0.000199	0.000186	0.000125	0.000244
	16	0.000154	0.000172	0.000169	0.000124
	32	0.000402	0.000350	0.000141	0.000139
comp	2	1.535572	1.569347	1.564301	1.577555
	4	0.738723	0.734743	0.744642	0.731976
	8	0.367912	0.364472	0.367257	0.368038
	16	0.183112	0.183989	0.183950	0.183911
	32	0.091695	0.091445	0.091805	0.092350
comp_large	2	0.269547	0.278110	0.273559	0.278216
	4	0.130207	0.130919	0.131146	0.128653

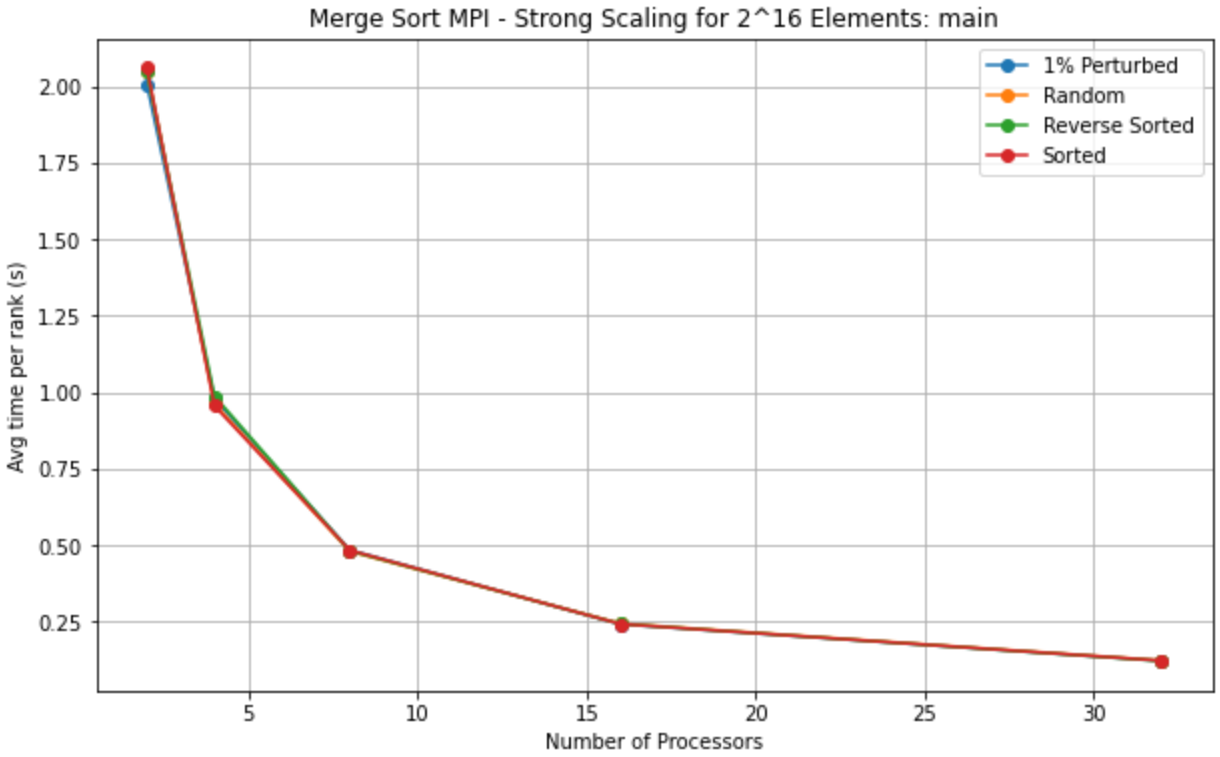
		1% Perturbed	Random	Reverse Sorted	Sorted
		Avg time/rank	Avg time/rank	Avg time/rank	Avg time/rank
name	num_procs				
	8	0.064983	0.064885	0.064475	0.064814
	16	0.032218	0.032673	0.032327	0.032319
	32	0.016105	0.016197	0.016141	0.016137
comp_small	2	0.265555	0.271780	0.270603	0.275518
	4	0.127941	0.127916	0.129896	0.127313
	8	0.064104	0.063125	0.063953	0.064217
	16	0.031717	0.031799	0.031987	0.032028
	32	0.015863	0.015793	0.015952	0.015978
correctness_check	2	0.000201	0.000194	0.000198	0.000200
	4	0.000190	0.000190	0.000193	0.000190
	8	0.000194	0.000189	0.000189	0.000194
	16	0.000190	0.000194	0.000194	0.000189
	32	0.000198	0.000210	0.000199	0.000192
data_init	2	0.000296	0.001585	0.000355	0.000266
	4	0.000293	0.001600	0.000353	0.000266
	8	0.000295	0.001590	0.000358	0.000265
	16	0.000298	0.001609	0.000362	0.000273
	32	0.000302	0.001590	0.000356	0.000300

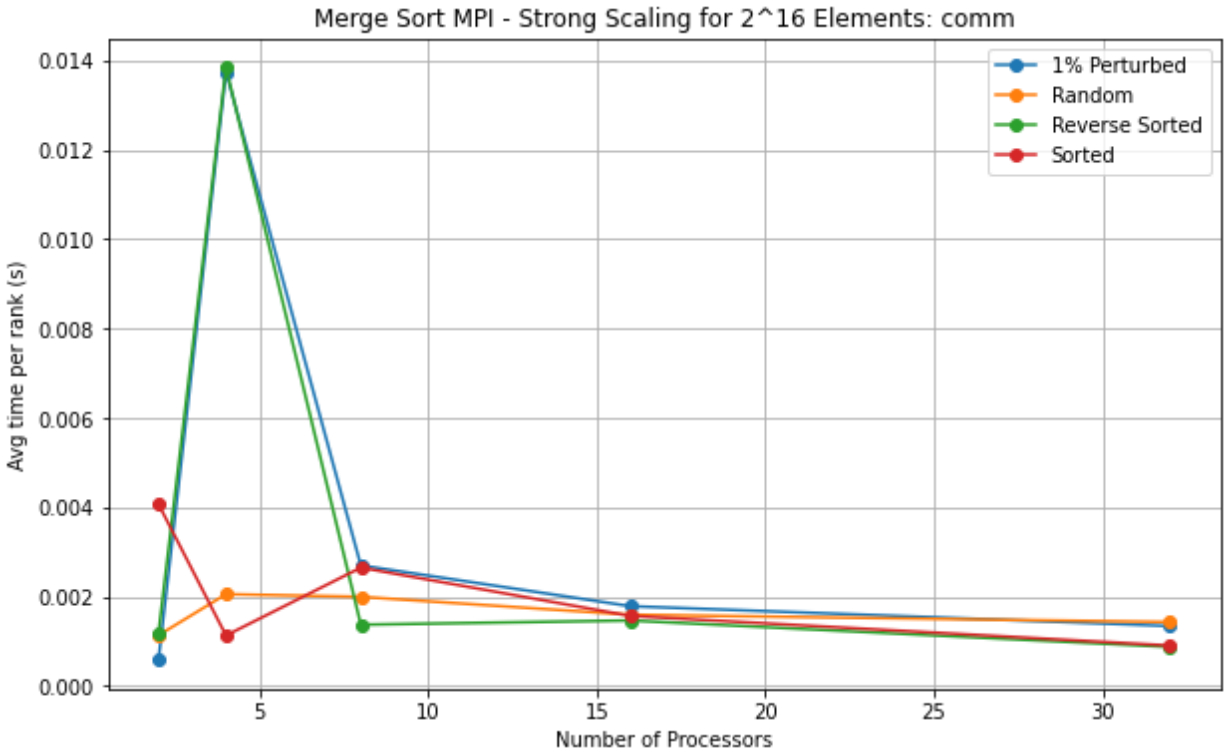
In [174…
```
main = ctk16.dataframe.loc["main"]
comm = ctk16.dataframe.loc["comm"]
comm_large = ctk16.dataframe.loc["comm_large"]
MPI_Gather = ctk16.dataframe.loc["MPI_Gather"]
MPI_Scatter = ctk16.dataframe.loc["MPI_Scatter"]
comp = ctk16.dataframe.loc["comp"]
comp_large = ctk16.dataframe.loc["comp_large"]
comp_small = ctk16.dataframe.loc["comp_small"]
correctness_check = ctk16.dataframe.loc["correctness_check"]
data_init = ctk16.dataframe.loc["data_init"]
```

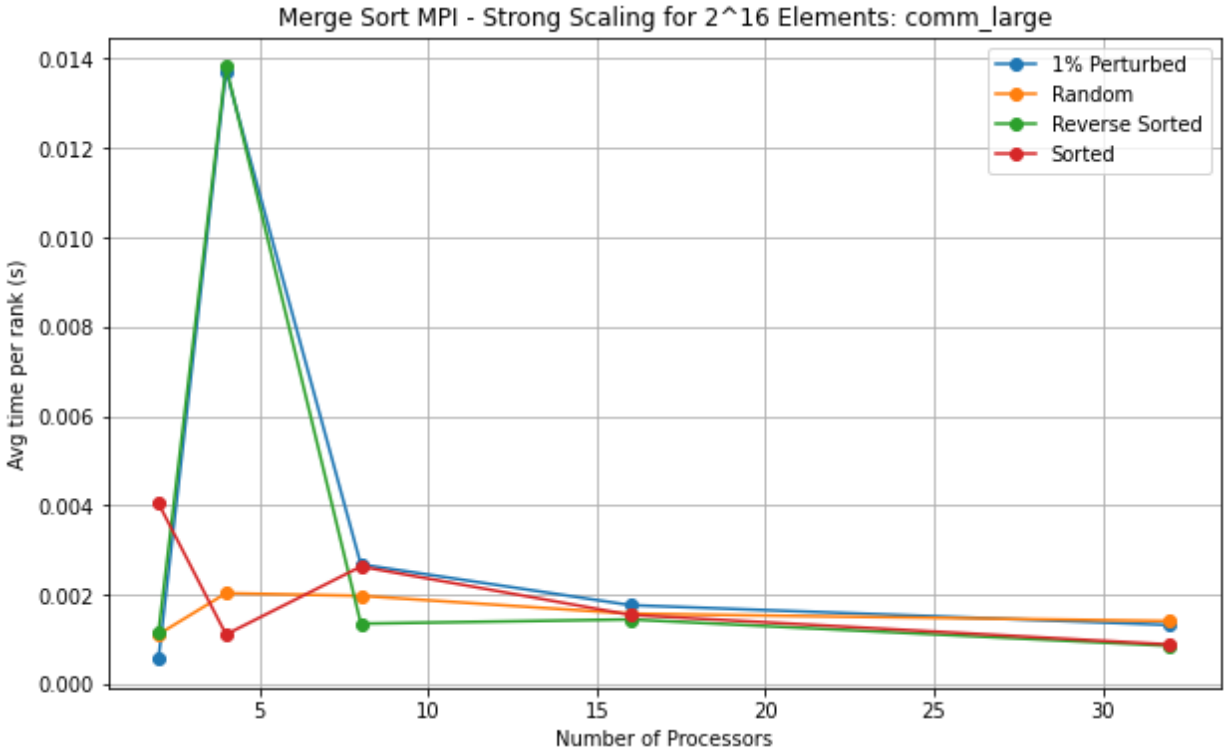
In [175…
```
regions = [main, comm, comm_large, MPI_Gather, MPI_Scatter, comp, comp_large, comp_sma
names = ["main", "comm", "comm_large", "MPI_Gather", "MPI_Scatter", "comp", "comp_larg
```

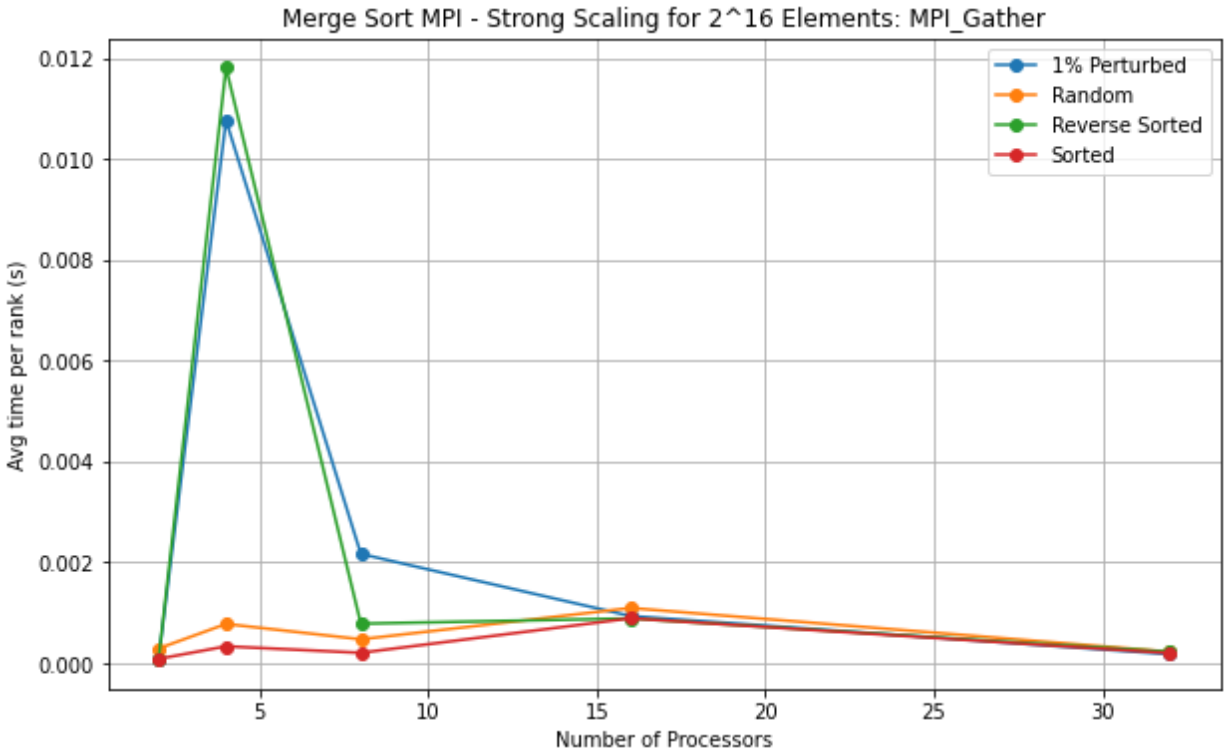
In [176…
```
for region, name in zip(regions, names):
    plt.figure(figsize=(10, 6))  # Adjust the figure size if needed
    legend_labels = []
    for column in region.columns:
        first_index = column[0]  # Extract the first index
        legend_labels.append(first_index)
        plt.plot(region.index, region.xs(column, axis=1), marker='o', label=column)
```

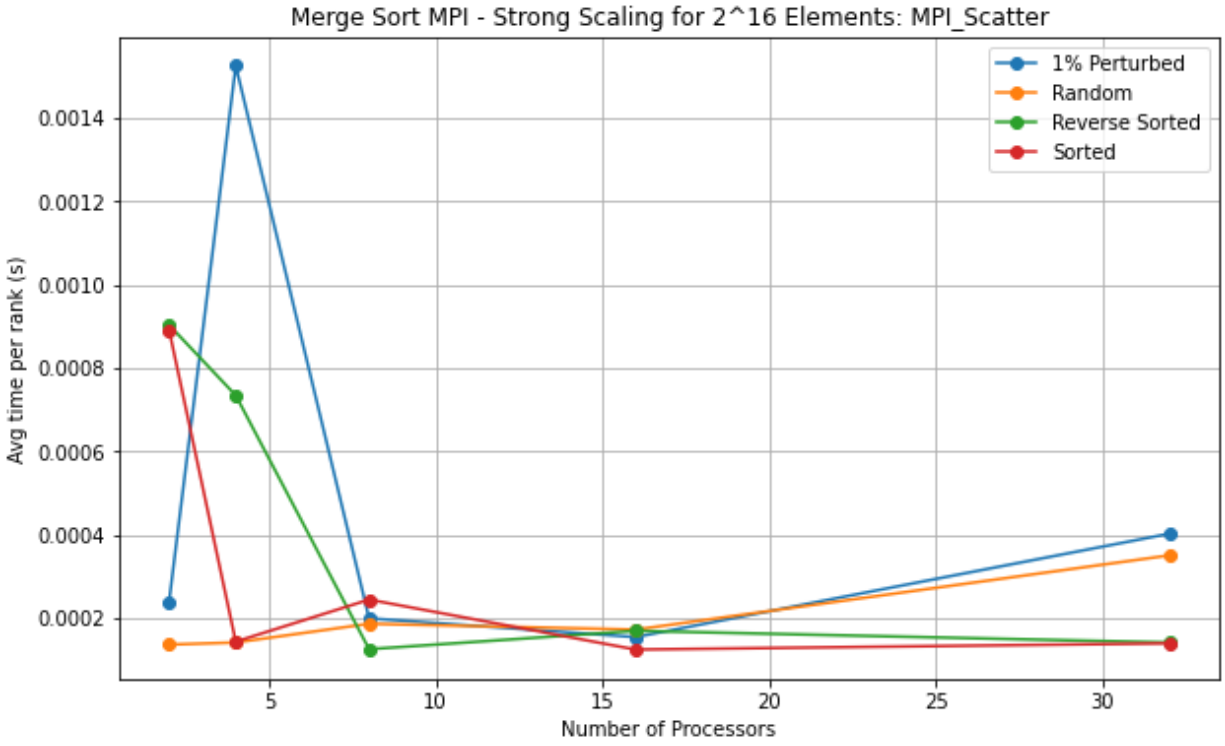
```
    plt.xlabel('Number of Processors')
    plt.ylabel('Avg time per rank (s)')
    plt.title(f'Merge Sort MPI - Strong Scaling for 2^16 Elements: {name}')
    plt.legend(legend_labels)
    plt.grid(True)
    plt.show()
```

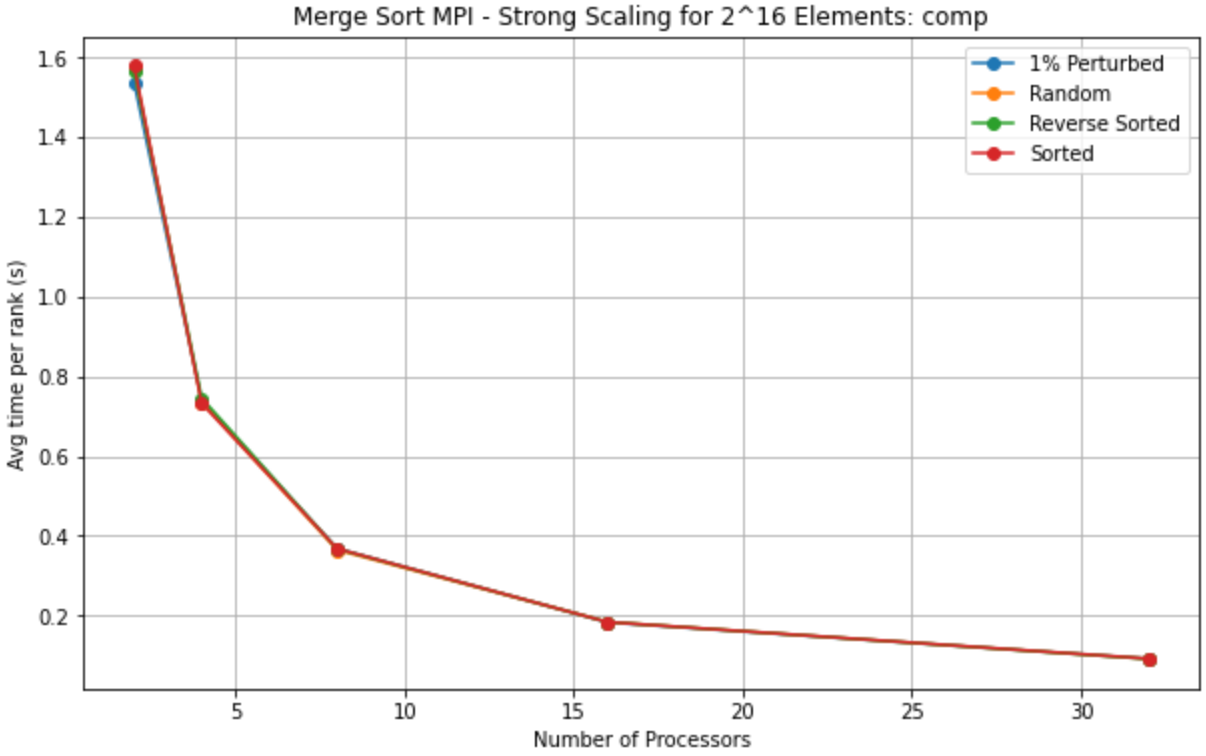


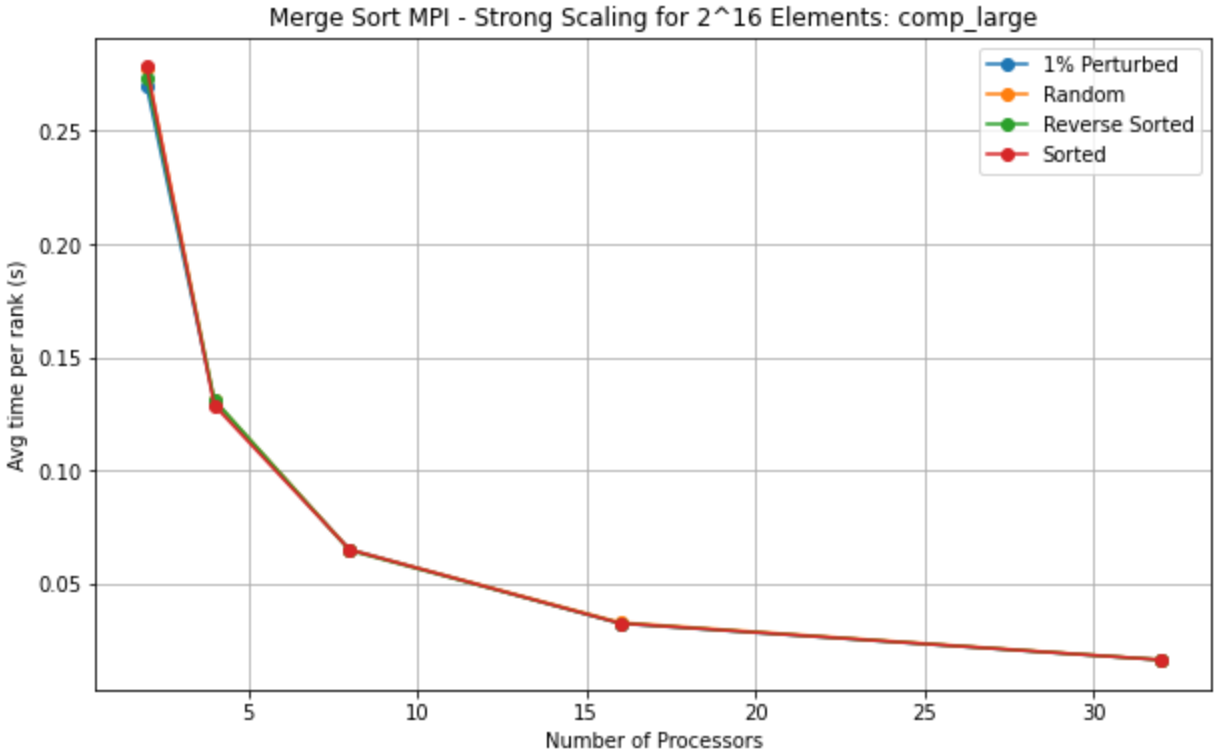


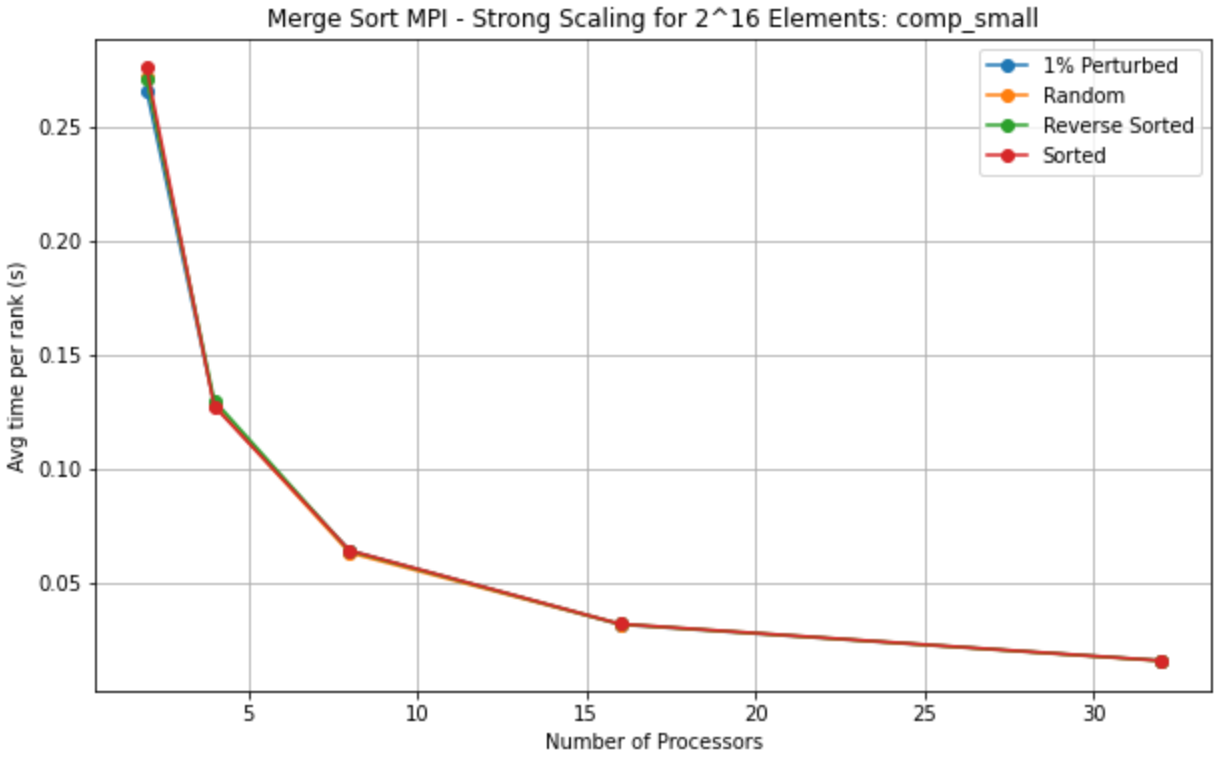

Merge Sort MPI - Strong Scaling for 2^16 Elements: comm_large
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
5
10
15
20
25
30

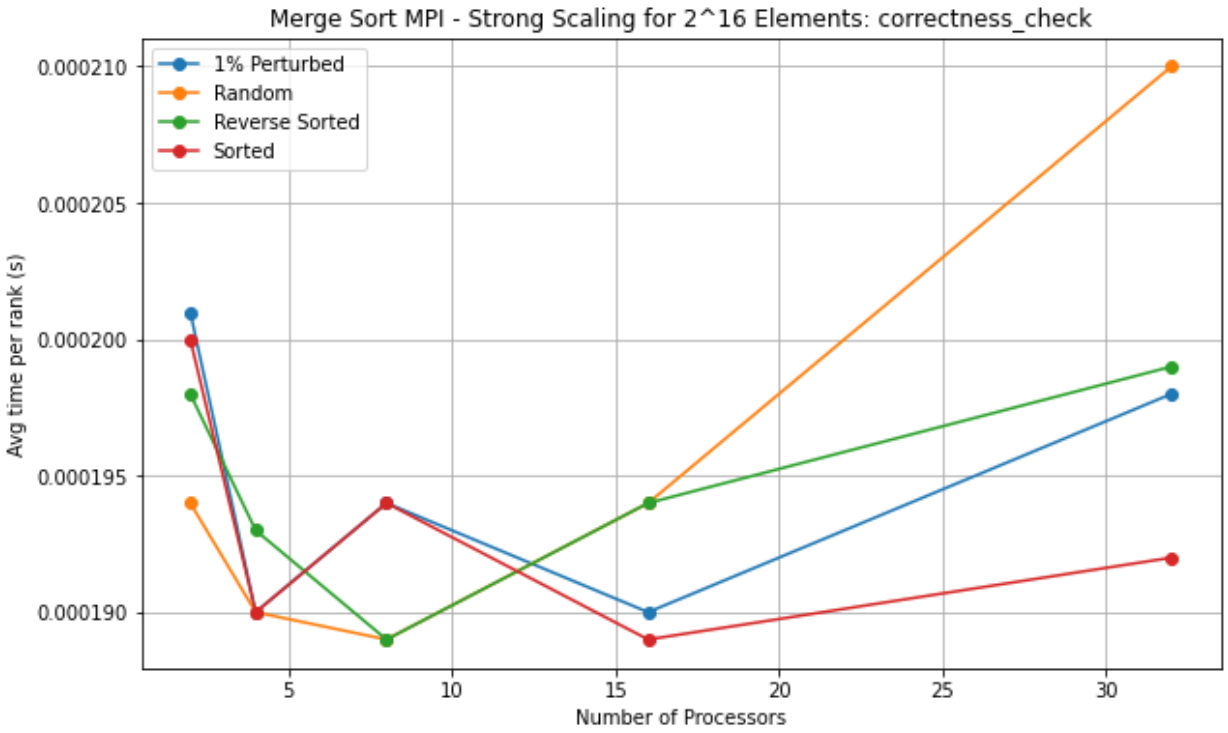

Merge Sort MPI - Strong Scaling for 2^16 Elements: MPI_Gather
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
0.000
0.002
0.004
0.006
0.008
0.010
0.012
5
10
15
20
25
30

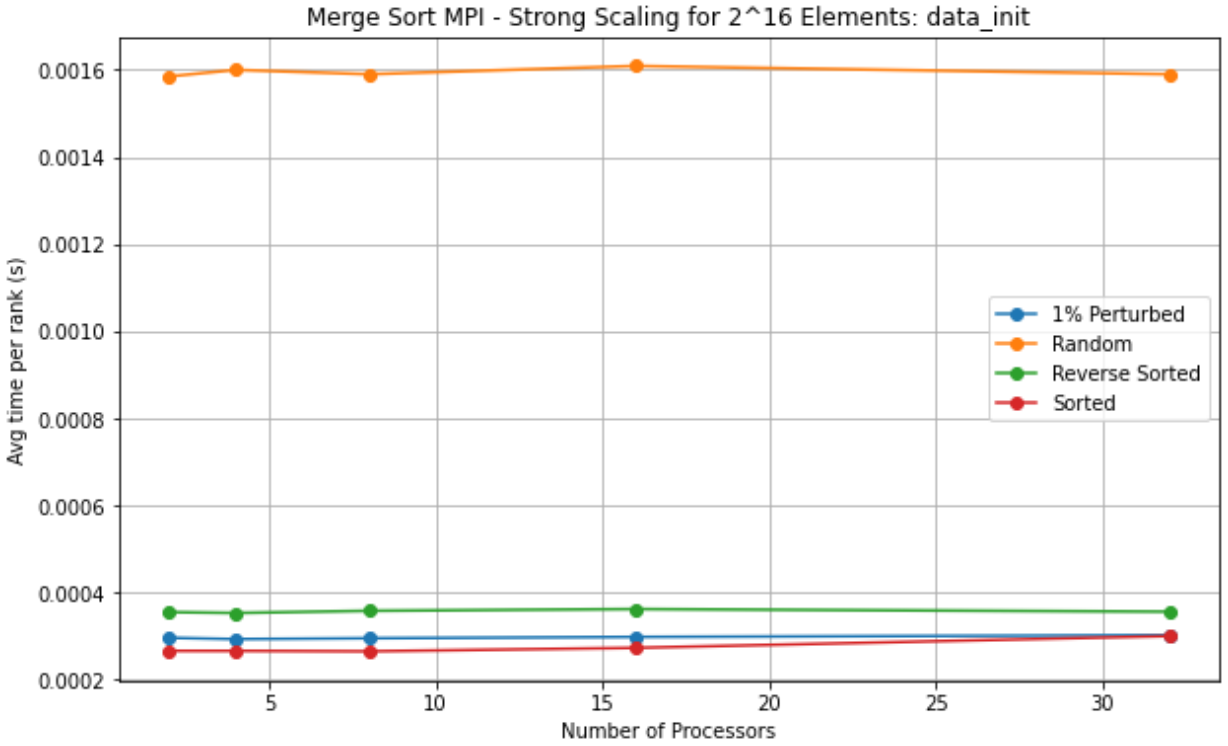

Merge Sort MPI - Strong Scaling for 2^16 Elements: MPI_Scatter
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
5
10
15
20
25
30
Number of Processors


Merge Sort MPI - Strong Scaling for 2^16 Elements: comp
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
5
10
15
20
25
30
Number of Processors


Merge Sort MPI - Strong Scaling for 2^16 Elements: comp_large
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
0.25
0.20
0.15
0.10
0.05
5
10
15
20
25
30
Number of Processors


Merge Sort MPI - Strong Scaling for 2^16 Elements: comp_small
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
0.25
0.20
0.15
0.10
0.05
5
10
15
20
25
30
Number of Processors





2^18

In [177…

```
tk18 = th.Thicket.from_caliperreader(glob("cali_data_missingLast2ArraySizes/*262144*.c
tk18.metadata
```

Out[177]:

profile	cali.caliper.version	mpi.world.size	spot.metrics	spot.tir
138396286	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
155268744	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
416744107	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
1115892024	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
1213334784	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
1503659809	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
2539699287	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
2541958536	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
2559769224	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
2573635784	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
2627811168	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
2987020596	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
3174926699	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
3246849008	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
3292727475	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
3354469146	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
3501904028	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
3703448966	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	

profile	cali.caliper.version	mpi.world.size	spot.metrics	spot.ti
3885317734	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
3901006457	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	

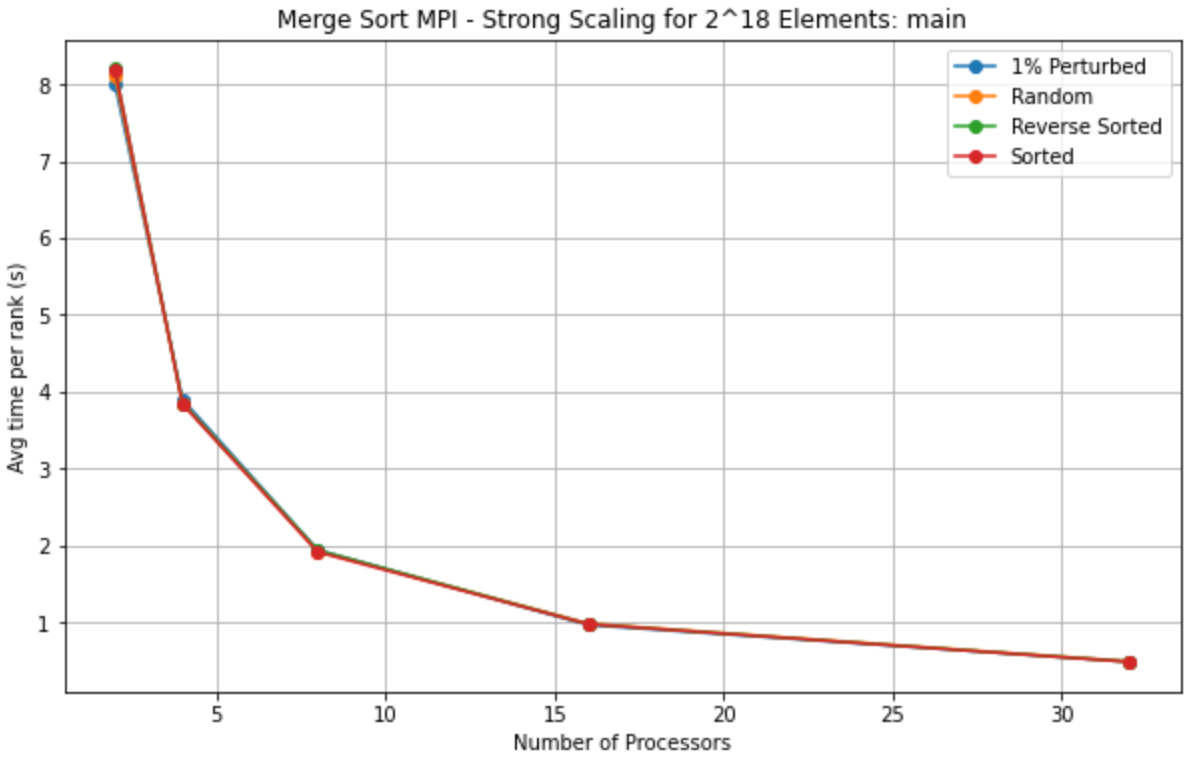
In [178…
```
gb18 = tk18.groupby("InputType")

ctk18 = th.Thicket.concat_thickets(
    thickets=list(gb18.values()),
    headers=list(gb18.keys()),
    axis='columns',
    metadata_key='num_procs'
)

ctk18.dataframe = ctk18.dataframe.reset_index().drop([("node", ""), ('1% Perturbed', '
                                                      ('Random', "nid"), ('Random', "s
                                                      ('Reverse Sorted', "nid"), ('Rev
                                                      ('Sorted', "nid"), ('Sorted', "s
                                                     ], axis=1)
ctk18.dataframe = ctk18.dataframe.rename({("name", ""): "name", ("num_procs", ""): "nu
```

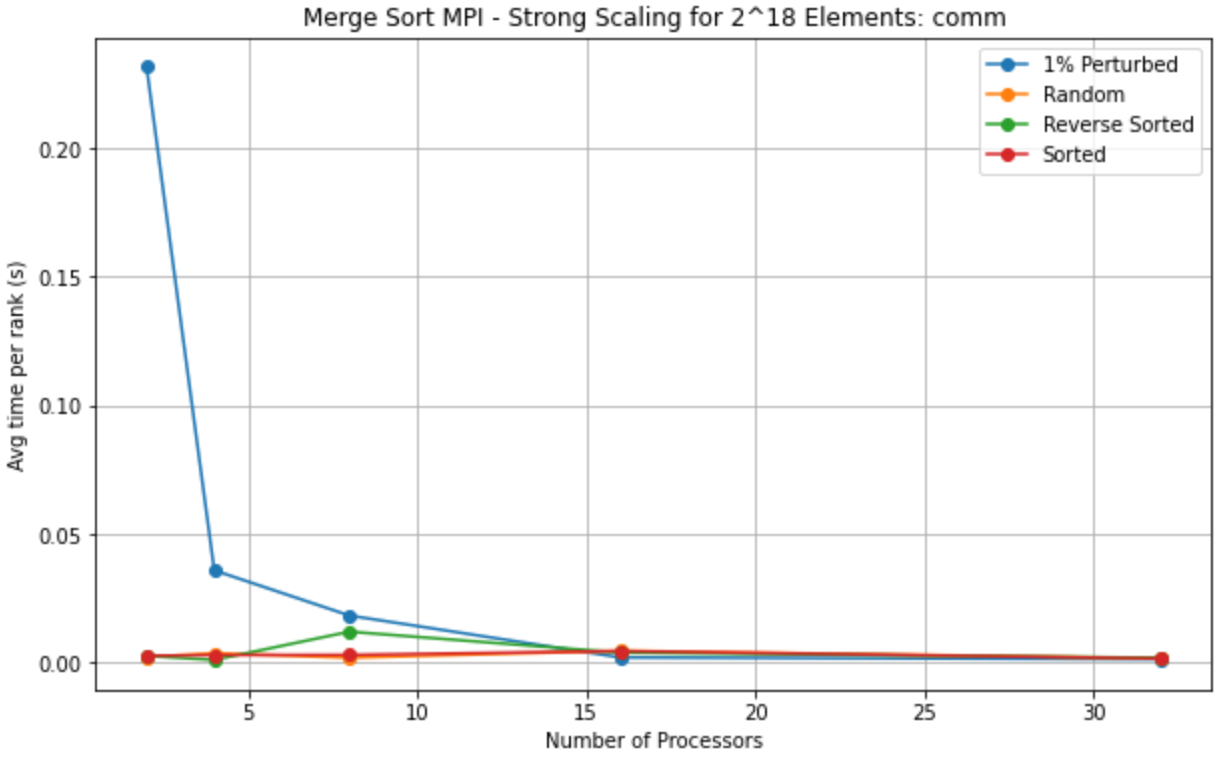
```
4  thickets created...
{'1% Perturbed': <thicket.thicket.Thicket object at 0x2b270690faf0>, 'Random': <thick
et.thicket.Thicket object at 0x2b2705b193d0>, 'Reverse Sorted': <thicket.thicket.Thic
ket object at 0x2b2704e317f0>, 'Sorted': <thicket.thicket.Thicket object at 0x2b27068
03cd0>}
```

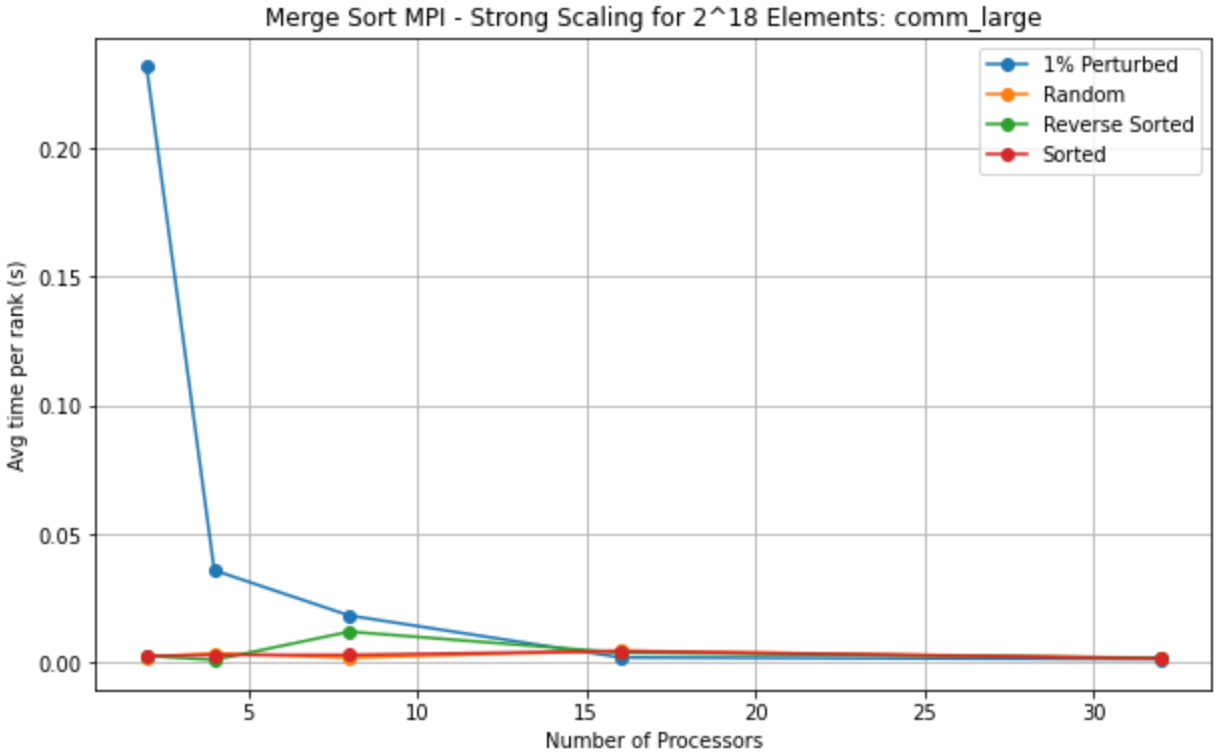
In [179…
```
main = ctk18.dataframe.loc["main"]
comm = ctk18.dataframe.loc["comm"]
comm_large = ctk18.dataframe.loc["comm_large"]
MPI_Gather = ctk18.dataframe.loc["MPI_Gather"]
MPI_Scatter = ctk18.dataframe.loc["MPI_Scatter"]
comp = ctk18.dataframe.loc["comp"]
comp_large = ctk18.dataframe.loc["comp_large"]
comp_small = ctk18.dataframe.loc["comp_small"]
correctness_check = ctk18.dataframe.loc["correctness_check"]
data_init = ctk18.dataframe.loc["data_init"]

regions = [main, comm, comm_large, MPI_Gather, MPI_Scatter, comp, comp_large, comp_sma
names = ["main", "comm", "comm_large", "MPI_Gather", "MPI_Scatter", "comp", "comp_larg
```

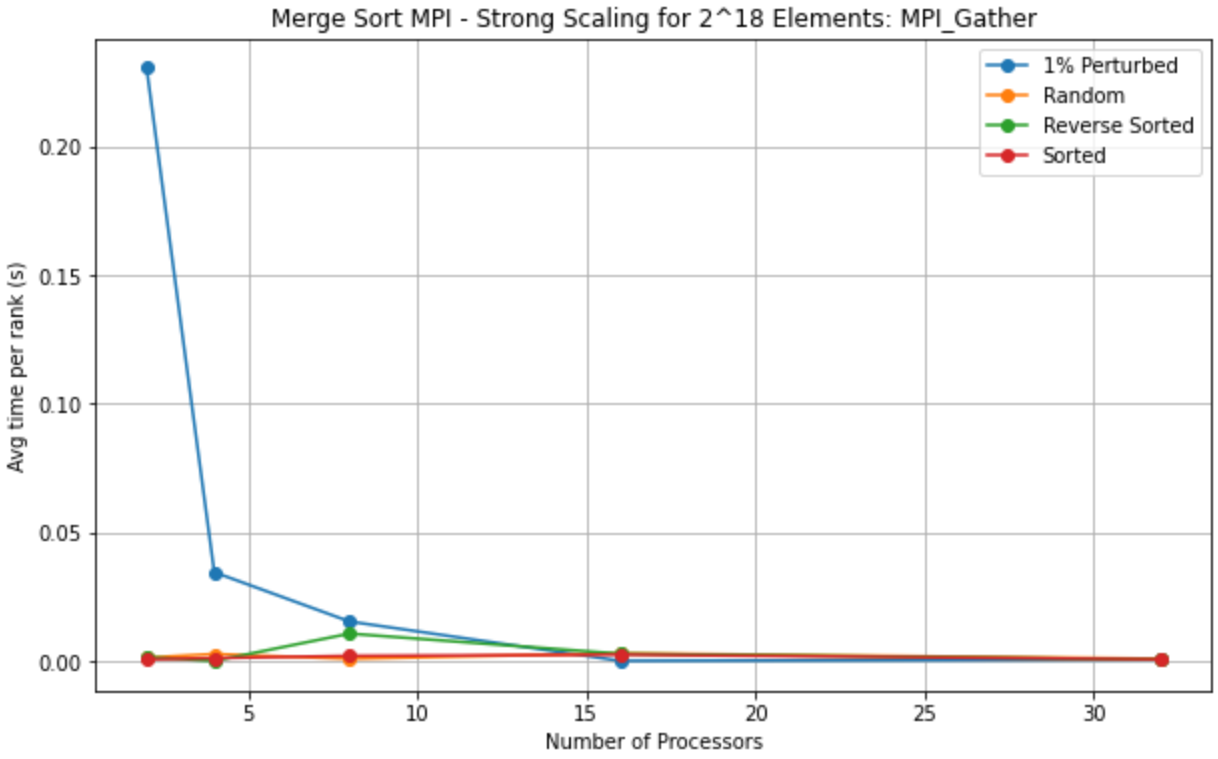
In [180…
```
for region, name in zip(regions, names):
    plt.figure(figsize=(10, 6))  # Adjust the figure size if needed
    legend_labels = []
    for column in region.columns:
        first_index = column[0]  # Extract the first index
        legend_labels.append(first_index)
        plt.plot(region.index, region.xs(column, axis=1), marker='o', label=column)

    plt.xlabel('Number of Processors')
    plt.ylabel('Avg time per rank (s)')
    plt.title(f'Merge Sort MPI - Strong Scaling for 2^18 Elements: {name}')
    plt.legend(legend_labels)
```

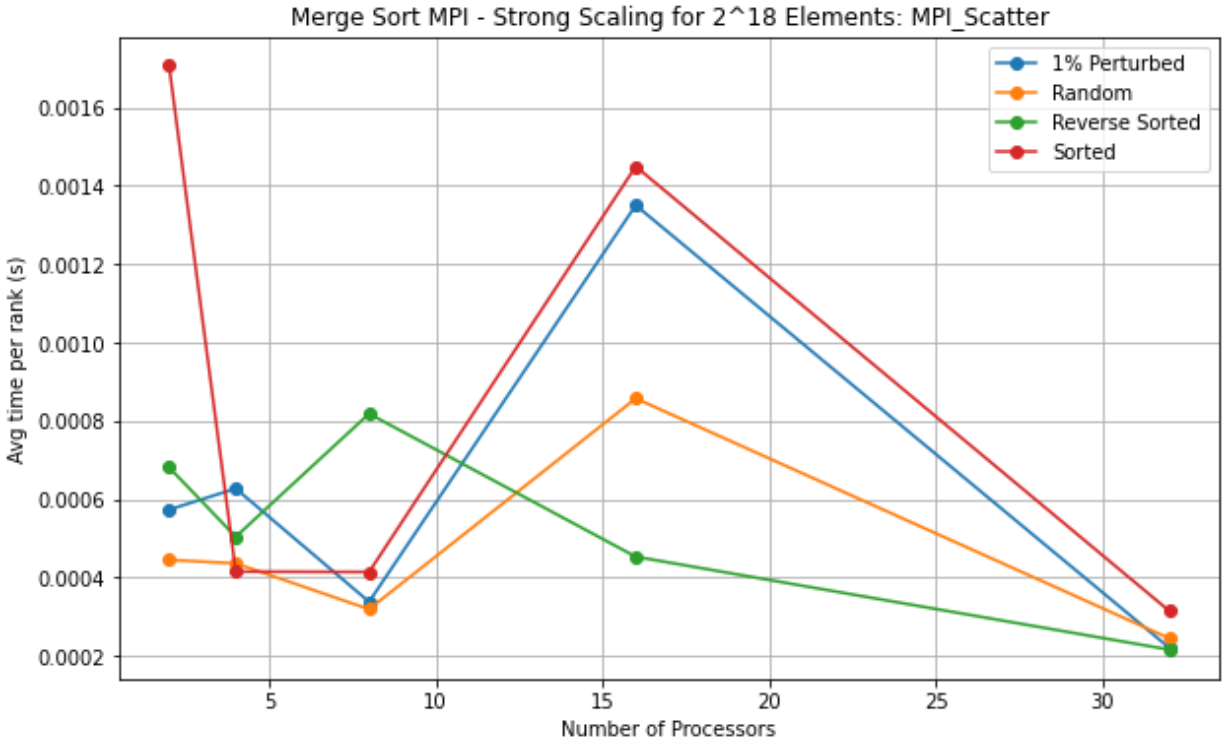
```
    plt.grid(True)
    plt.show()
```

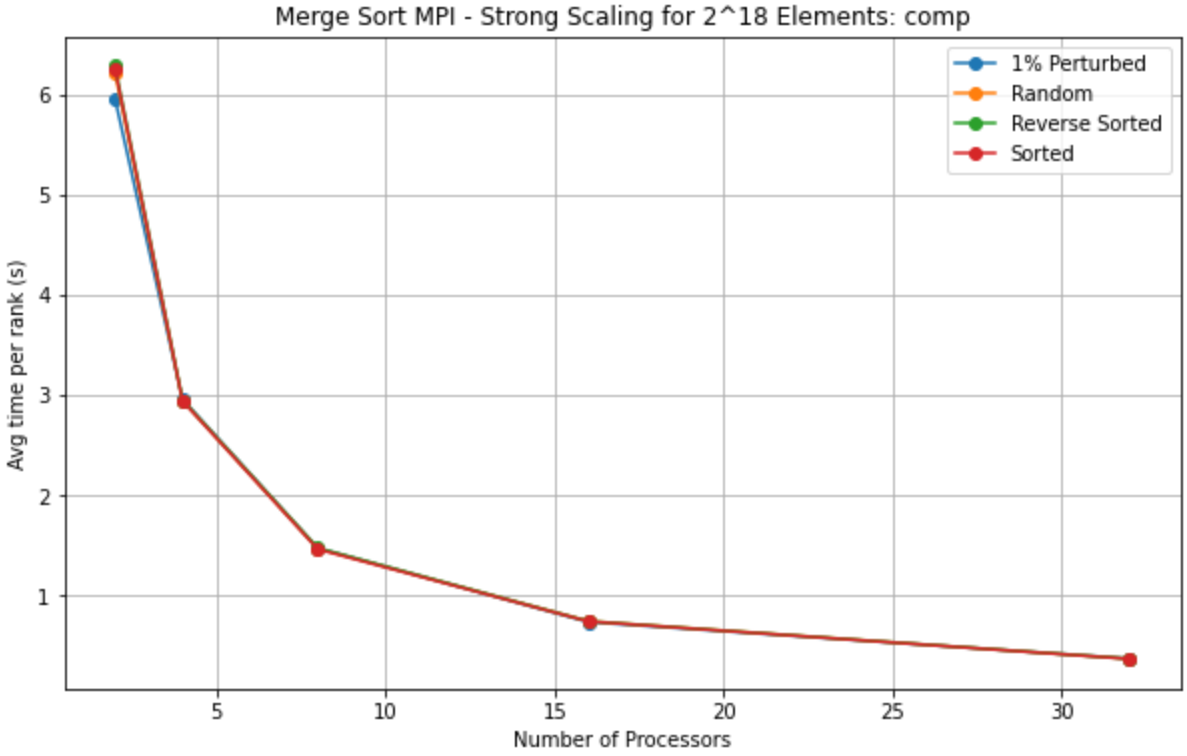


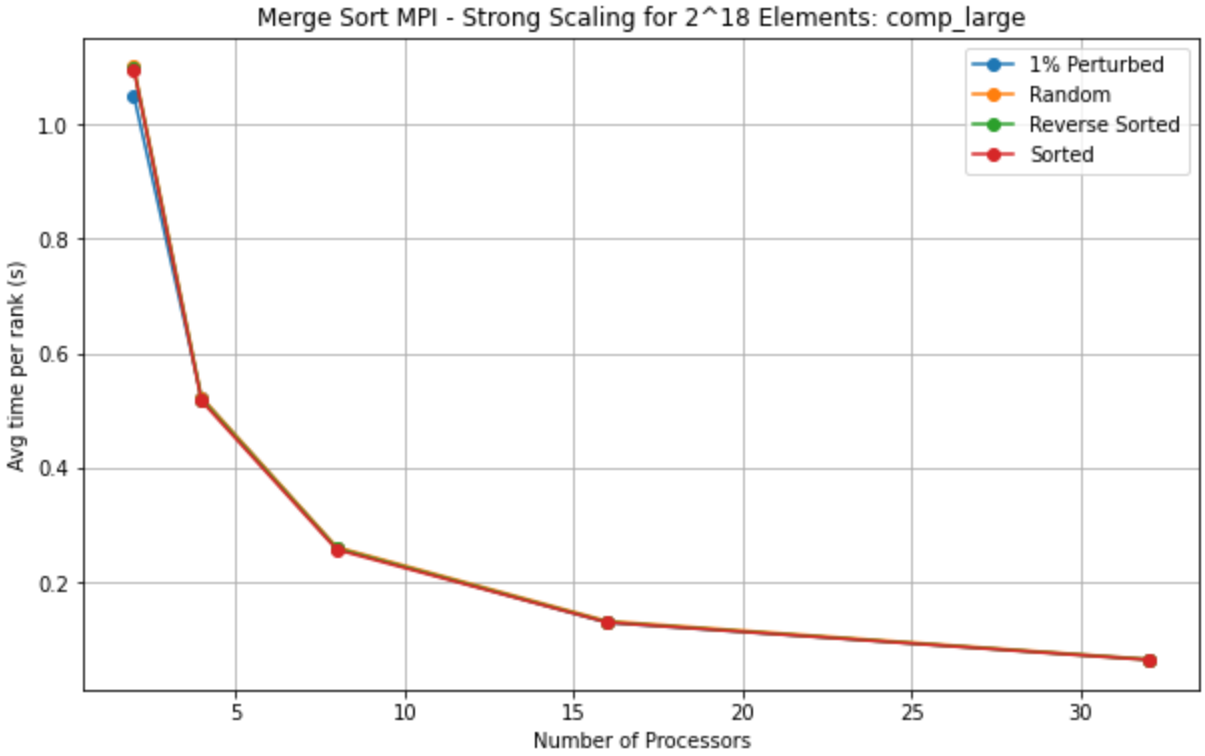


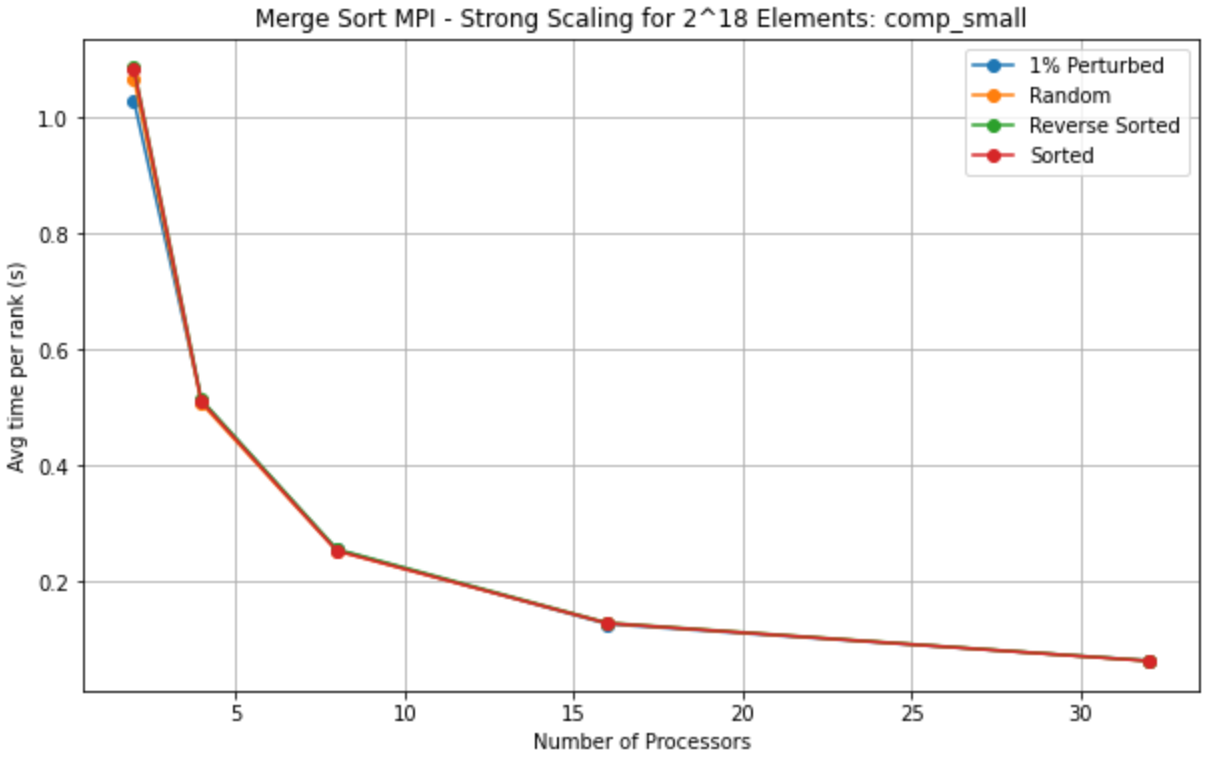

Merge Sort MPI - Strong Scaling for 2^18 Elements: comm_large
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
0.00
0.05
0.10
0.15
0.20
5
10
15
20
25
30
Number of Processors

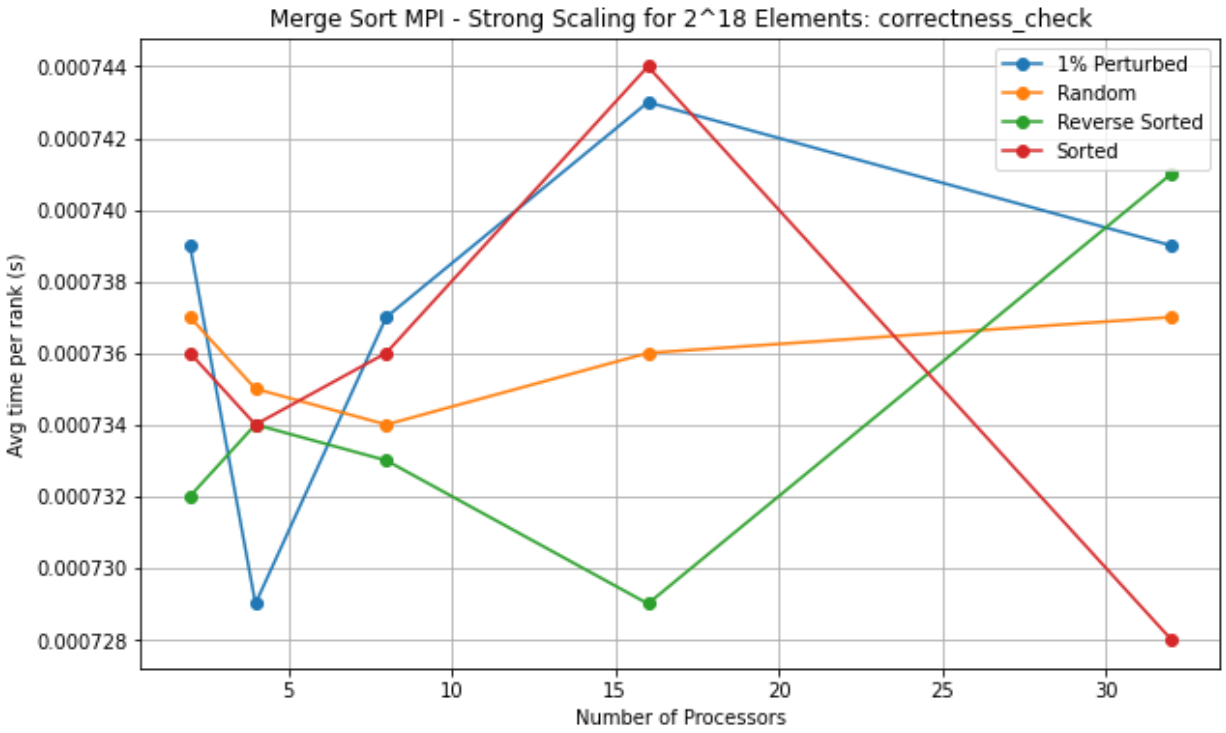

Merge Sort MPI - Strong Scaling for 2^18 Elements: MPI_Gather
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
0.00
0.05
0.10
0.15
0.20
5
10
15
20
25
30
Number of Processors

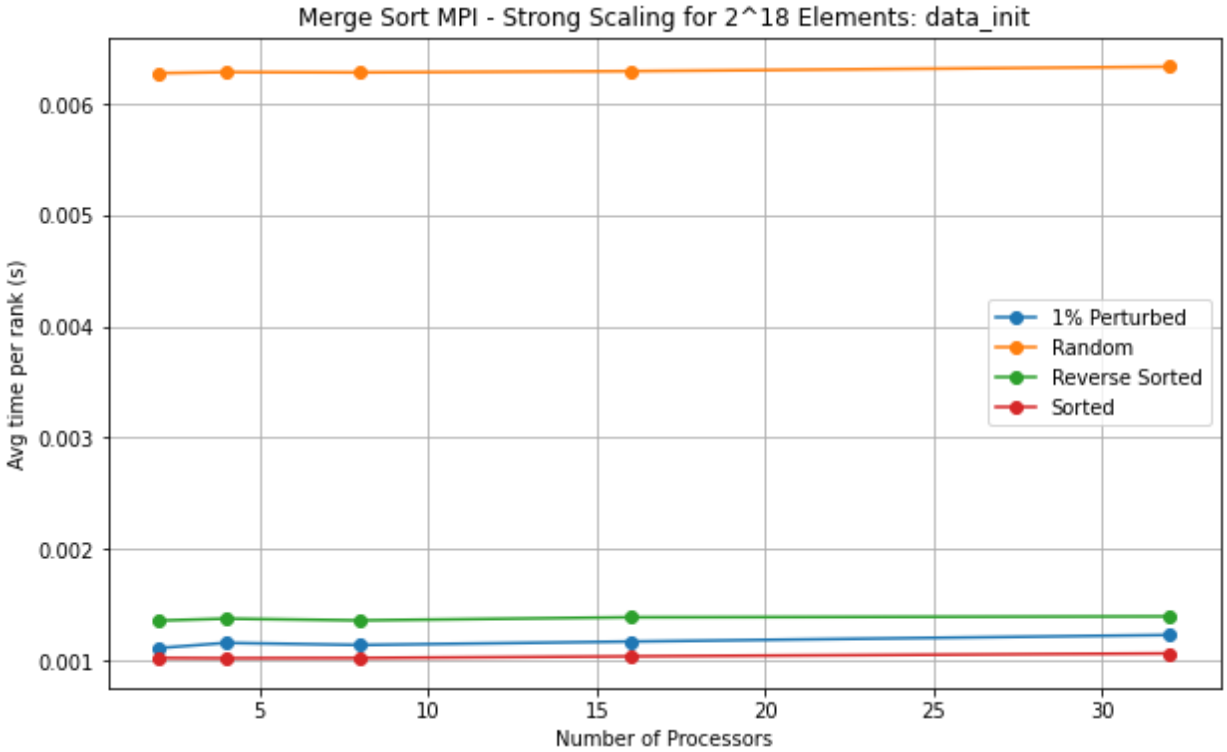

Merge Sort MPI - Strong Scaling for 2^18 Elements: MPI_Scatter
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
5
10
15
20
25
30
Number of Processors


Merge Sort MPI - Strong Scaling for 2^18 Elements: comp
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
6
5
4
3
2
1
5
10
15
20
25
30
Number of Processors


Merge Sort MPI - Strong Scaling for 2^18 Elements: comp_large
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
1.0
0.8
0.6
0.4
0.2
5
10
15
20
25
30


Merge Sort MPI - Strong Scaling for 2^18 Elements: comp_small
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
1.0
0.8
0.6
0.4
0.2
5
10
15
20
25
30





2^20

In [181…

```
tk20 = th.Thicket.from_caliperreader(glob("cali_data_missingLast2ArraySizes/*1048576*.
tk20.metadata
```

Out[181]:

profile	cali.caliper.version	mpi.world.size	spot.metrics	spot.tir
44630724	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
142342570	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
183390374	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
361958110	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
517965158	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
766175866	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
1304326797	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
1822854501	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
1928529805	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
1929219922	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
2209710391	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
2220061052	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
2461272367	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
2479501455	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
2520192252	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	

profile	cali.caliper.version	mpi.world.size	spot.metrics	spot.tir
2790631748	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
2884907900	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
3142565624	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
3268758192	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
3307632477	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	

In [182…

```
gb20 = tk20.groupby("InputType")

ctk20 = th.Thicket.concat_thickets(
    thickets=list(gb20.values()),
    headers=list(gb20.keys()),
    axis='columns',
    metadata_key='num_procs'
)

ctk20.dataframe = ctk20.dataframe.reset_index().drop([("node", ""), ('1% Perturbed', '
                                                      ('Random', "nid"), ('Random', "s
                                                      ('Reverse Sorted', "nid"), ('Rev
                                                      ('Sorted', "nid"), ('Sorted', "s
                                                     ], axis=1)
ctk20.dataframe = ctk20.dataframe.rename({("name", ""): "name", ("num_procs", ""): "nu
```

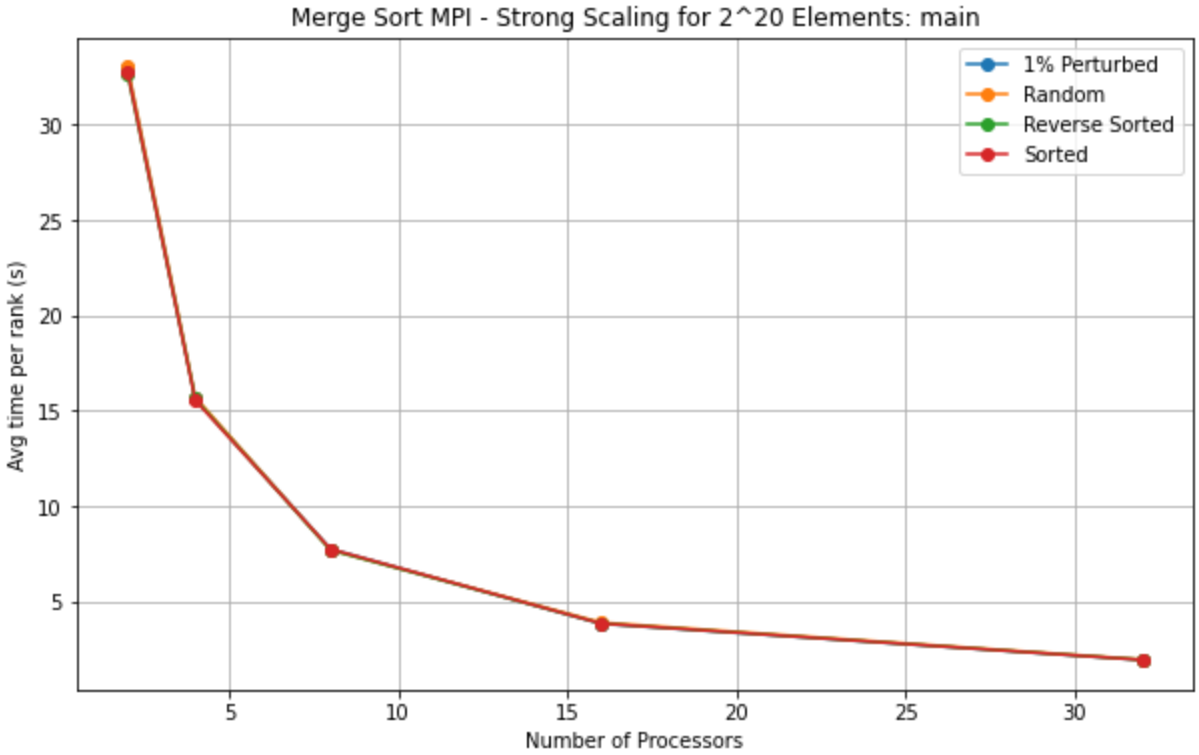
```
4  thickets created...
{'1% Perturbed': <thicket.thicket.Thicket object at 0x2b2704e66100>, 'Random': <thick
et.thicket.Thicket object at 0x2b2705151a90>, 'Reverse Sorted': <thicket.thicket.Thic
ket object at 0x2b2706c0d4f0>, 'Sorted': <thicket.thicket.Thicket object at 0x2b2706b
8e700>}
```

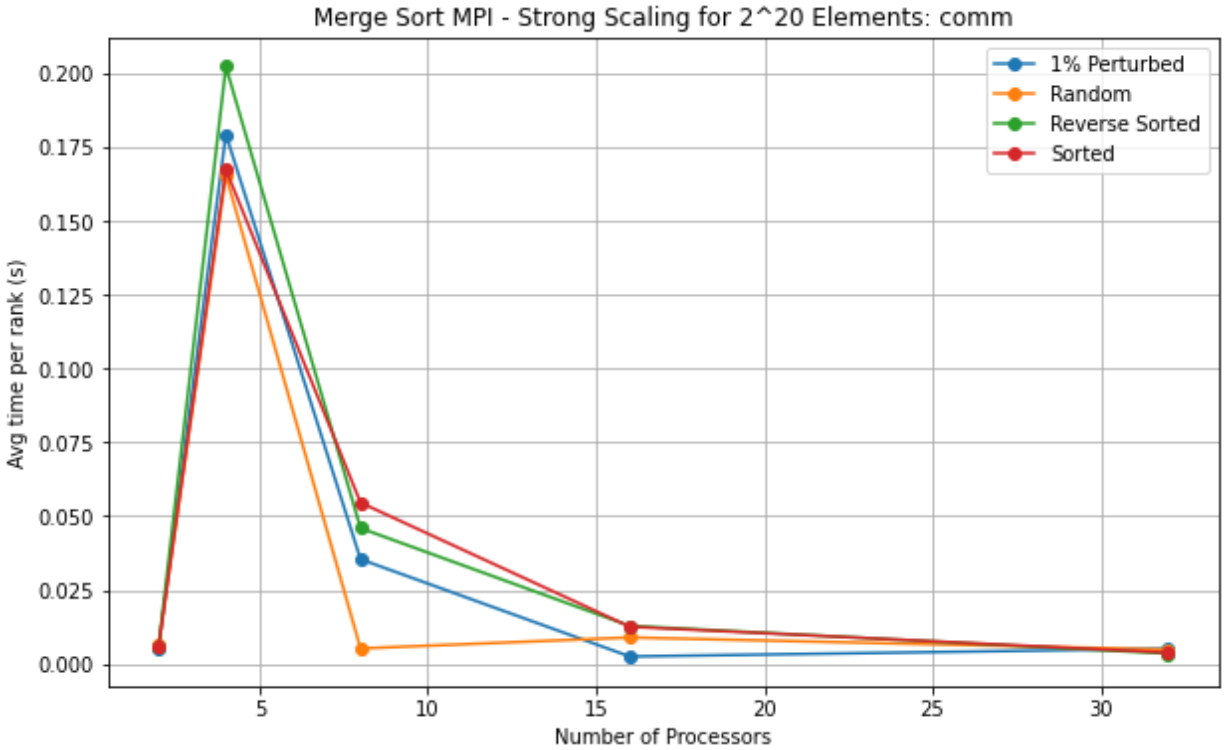
In [183…

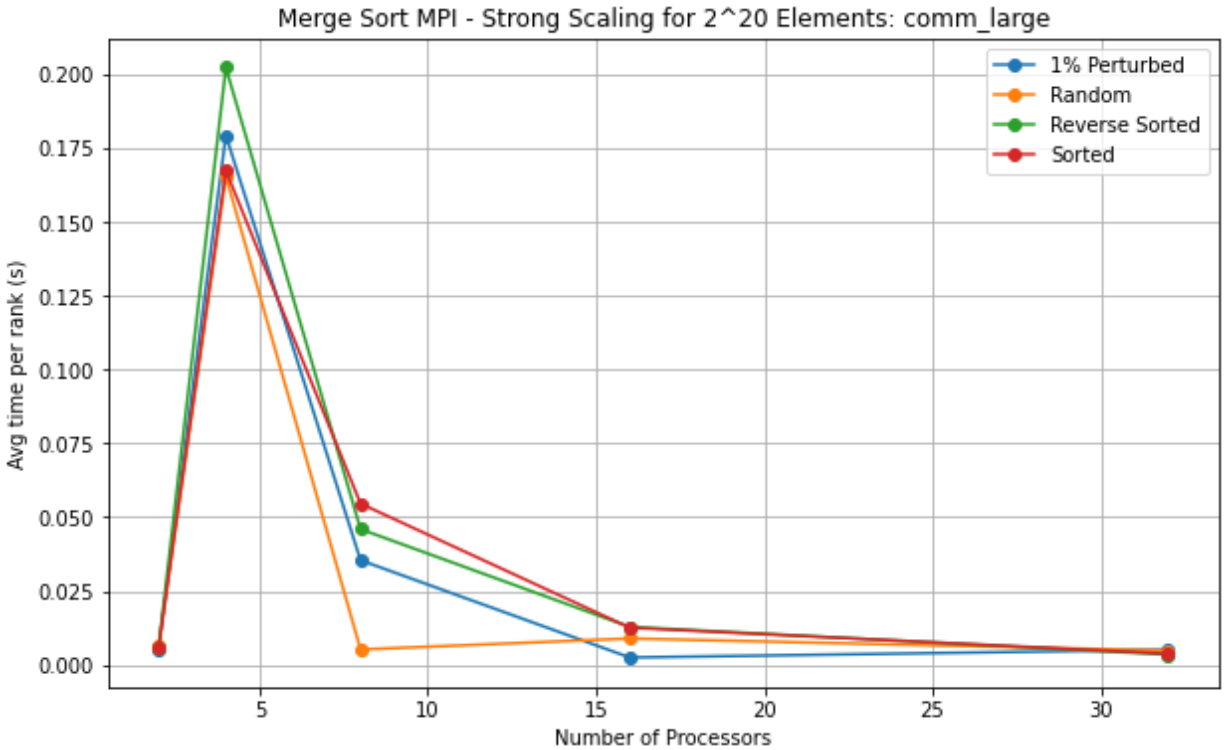
```
main = ctk20.dataframe.loc["main"]
comm = ctk20.dataframe.loc["comm"]
comm_large = ctk20.dataframe.loc["comm_large"]
MPI_Gather = ctk20.dataframe.loc["MPI_Gather"]
MPI_Scatter = ctk20.dataframe.loc["MPI_Scatter"]
comp = ctk20.dataframe.loc["comp"]
comp_large = ctk20.dataframe.loc["comp_large"]
comp_small = ctk20.dataframe.loc["comp_small"]
correctness_check = ctk20.dataframe.loc["correctness_check"]
data_init = ctk20.dataframe.loc["data_init"]

regions = [main, comm, comm_large, MPI_Gather, MPI_Scatter, comp, comp_large, comp_sma
names = ["main", "comm", "comm_large", "MPI_Gather", "MPI_Scatter", "comp", "comp_larg
```

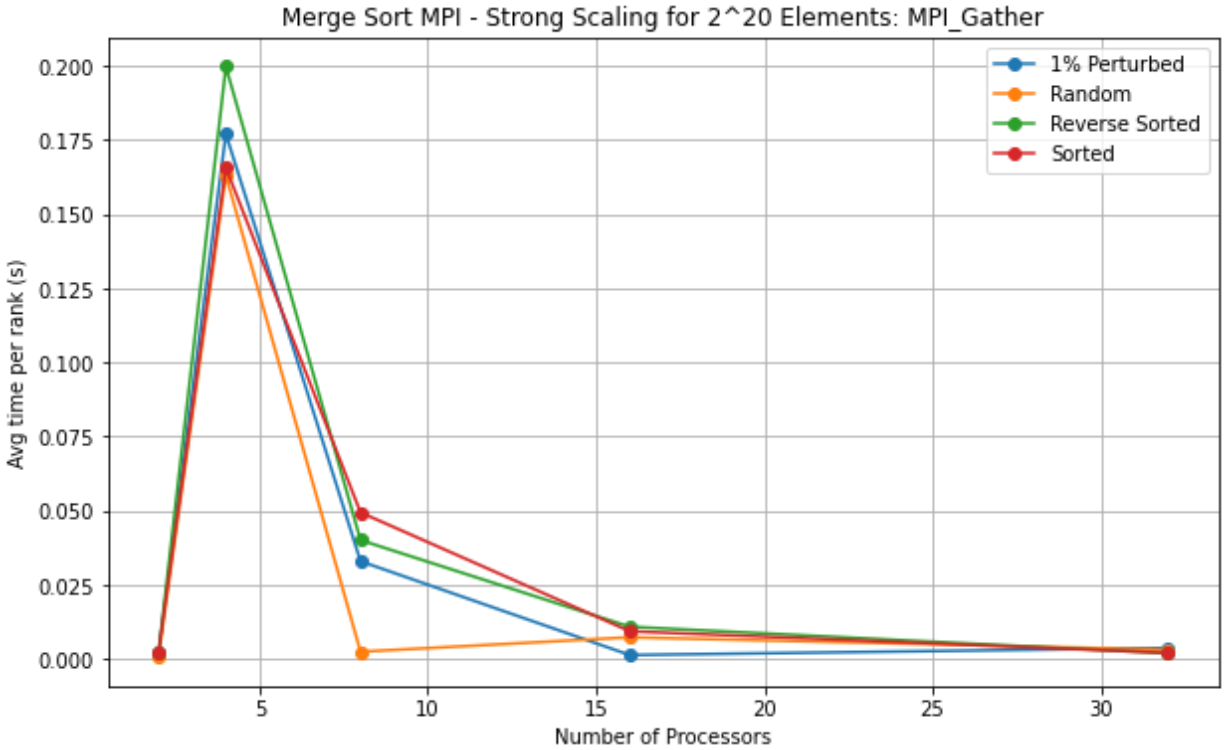
In [184…

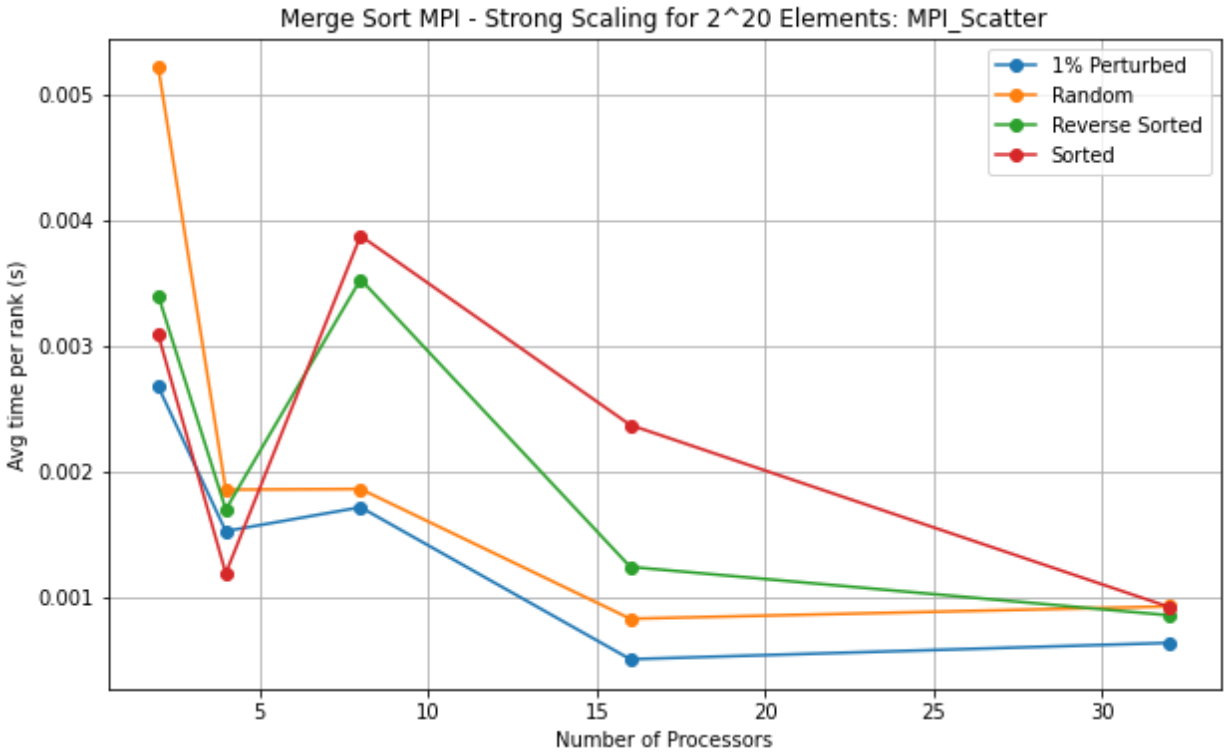
```
for region, name in zip(regions, names):
    plt.figure(figsize=(10, 6))  # Adjust the figure size if needed
    legend_labels = []
    for column in region.columns:
        first_index = column[0]  # Extract the first index
        legend_labels.append(first_index)
        plt.plot(region.index, region.xs(column, axis=1), marker='o', label=column)

    plt.xlabel('Number of Processors')
    plt.ylabel('Avg time per rank (s)')
    plt.title(f'Merge Sort MPI - Strong Scaling for 2^20 Elements: {name}')
    plt.legend(legend_labels)
    plt.grid(True)
    plt.show()
```

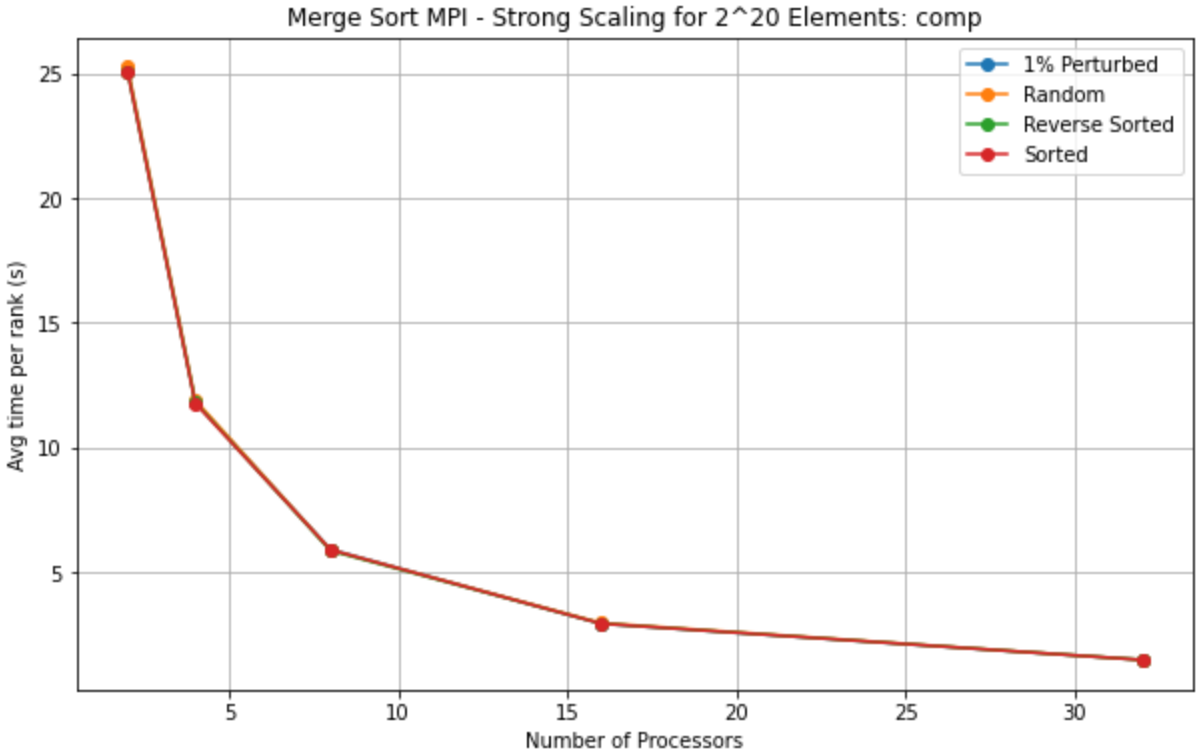


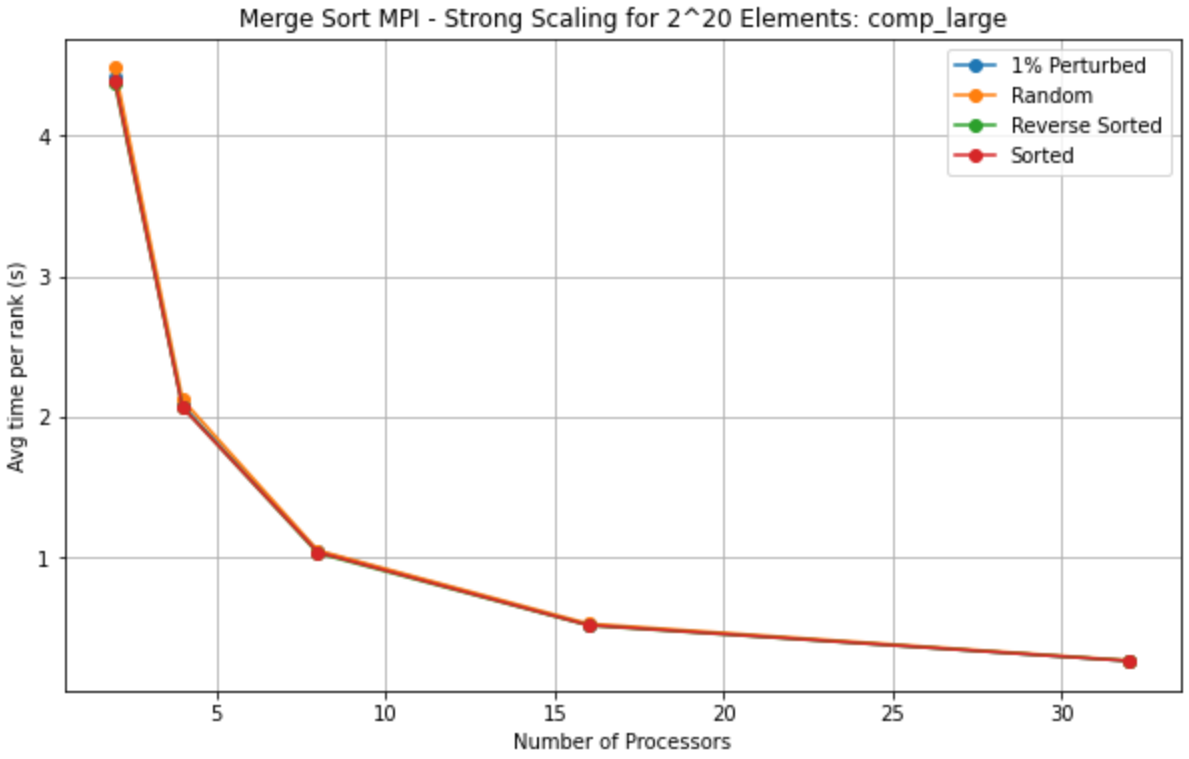

Merge Sort MPI - Strong Scaling for 2^20 Elements: comm
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
5
10
15
20
25
30
Number of Processors

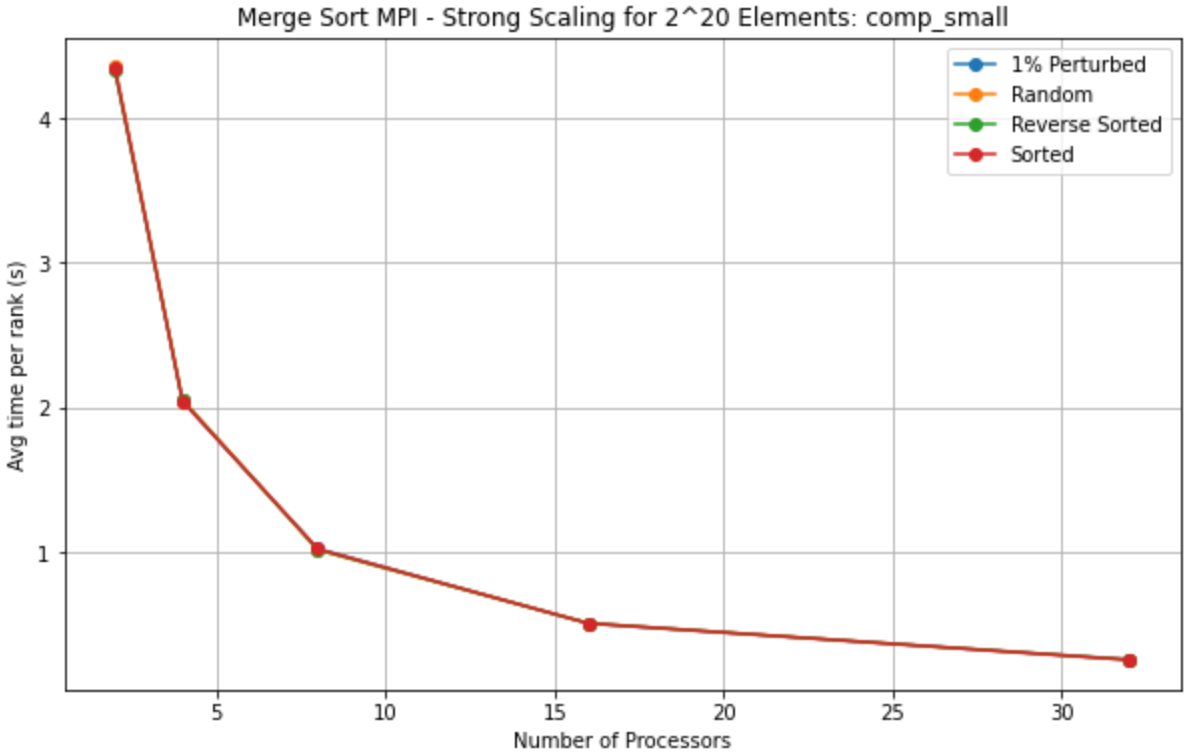

Merge Sort MPI - Strong Scaling for 2^20 Elements: comm_large
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
5
10
15
20
25
30
Number of Processors

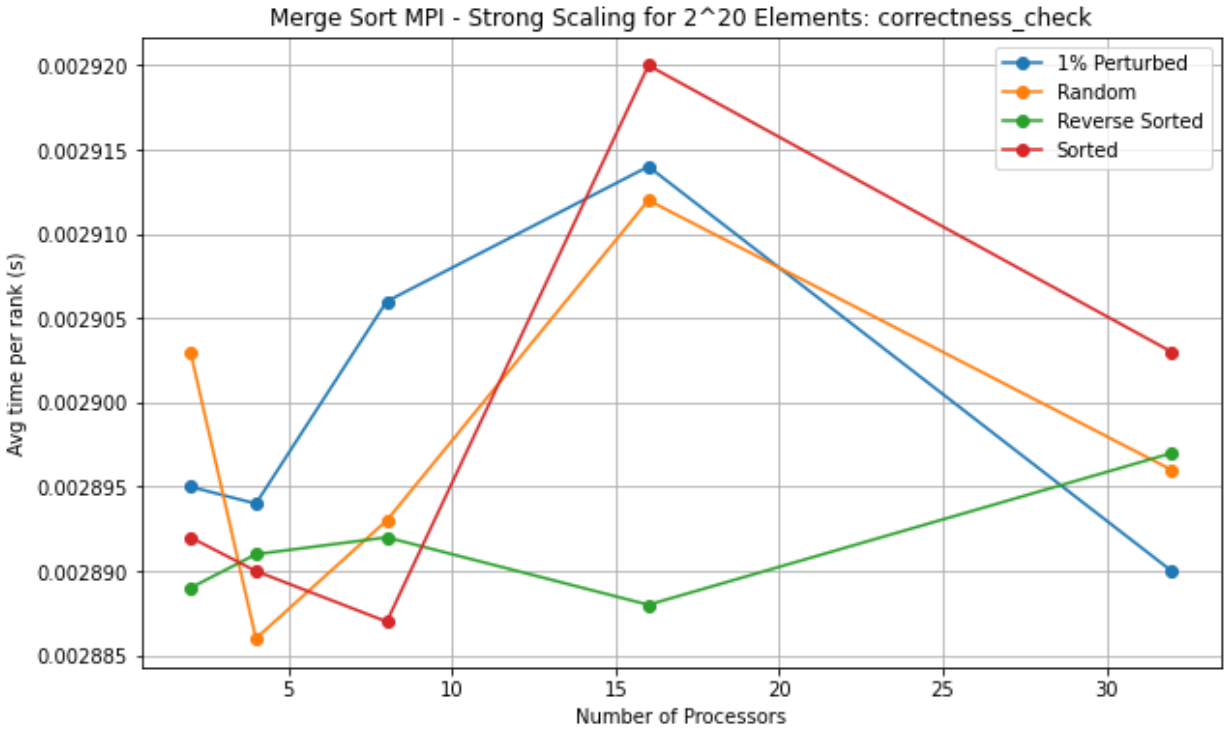

Merge Sort MPI - Strong Scaling for 2^20 Elements: MPI_Gather
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
5
10
15
20
25
30
Number of Processors

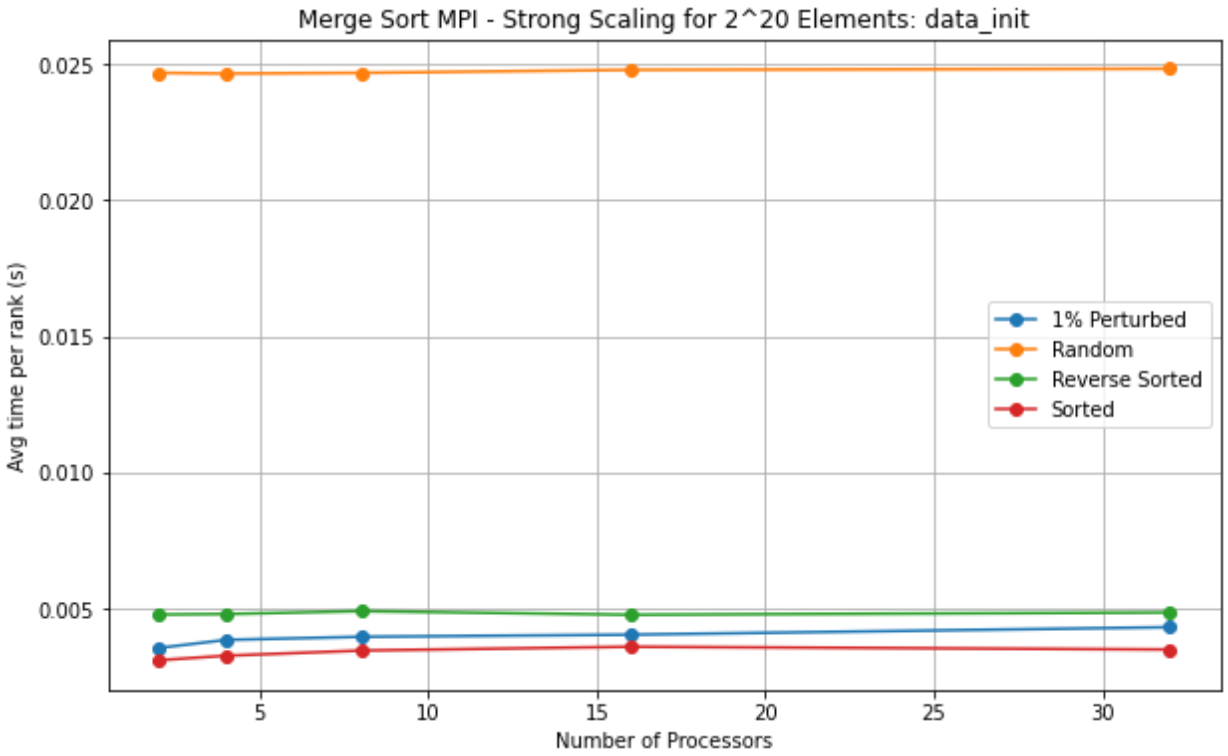

Merge Sort MPI - Strong Scaling for 2^20 Elements: MPI_Scatter
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
0.005
0.004
0.003
0.002
0.001
5
10
15
20
25
30
Number of Processors


Merge Sort MPI - Strong Scaling for 2^20 Elements: comp
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
25
20
15
10
5
5
10
15
20
25
30


Merge Sort MPI - Strong Scaling for 2^20 Elements: comp_large
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
4
3
2
1
5
10
15
20
25
30


Merge Sort MPI - Strong Scaling for 2^20 Elements: comp_small
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
1
2
3
4
5
10
15
20
25
30


Merge Sort MPI - Strong Scaling for 2^20 Elements: correctness_check
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
0.002885
0.002890
0.002895
0.002900
0.002905
0.002910
0.002915
0.002920
5
10
15
20
25
30



2^22

In [185…

```
tk22 = th.Thicket.from_caliperreader(glob("cali_data_missingLast2ArraySizes/*4194304*.
tk22.metadata
```

Out[185]:

profile	cali.caliper.version	mpi.world.size	spot.metrics	spot.tir
78787660	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
720821050	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
749725081	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
800875534	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
990792678	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
1001904923	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
1141460979	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
1302915350	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
1448023350	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
1484837794	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
1528221302	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
1814830269	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
2343626921	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
2521240440	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
2742590188	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	

profile	cali.caliper.version	mpi.world.size	spot.metrics	spot.tir
2928818902	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
3145627662	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
3378489513	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
4061888621	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
4195057121	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	

In [186…

```
gb22 = tk22.groupby("InputType")

ctk22 = th.Thicket.concat_thickets(
    thickets=list(gb22.values()),
    headers=list(gb22.keys()),
    axis='columns',
    metadata_key='num_procs'
)

ctk22.dataframe = ctk22.dataframe.reset_index().drop([("node", ""), ('1% Perturbed', '
                                                      ('Random', "nid"), ('Random', "s
                                                      ('Reverse Sorted', "nid"), ('Rev
                                                      ('Sorted', "nid"), ('Sorted', "s
                                                     ], axis=1)
ctk22.dataframe = ctk22.dataframe.rename({("name", ""): "name", ("num_procs", ""): "nu
```

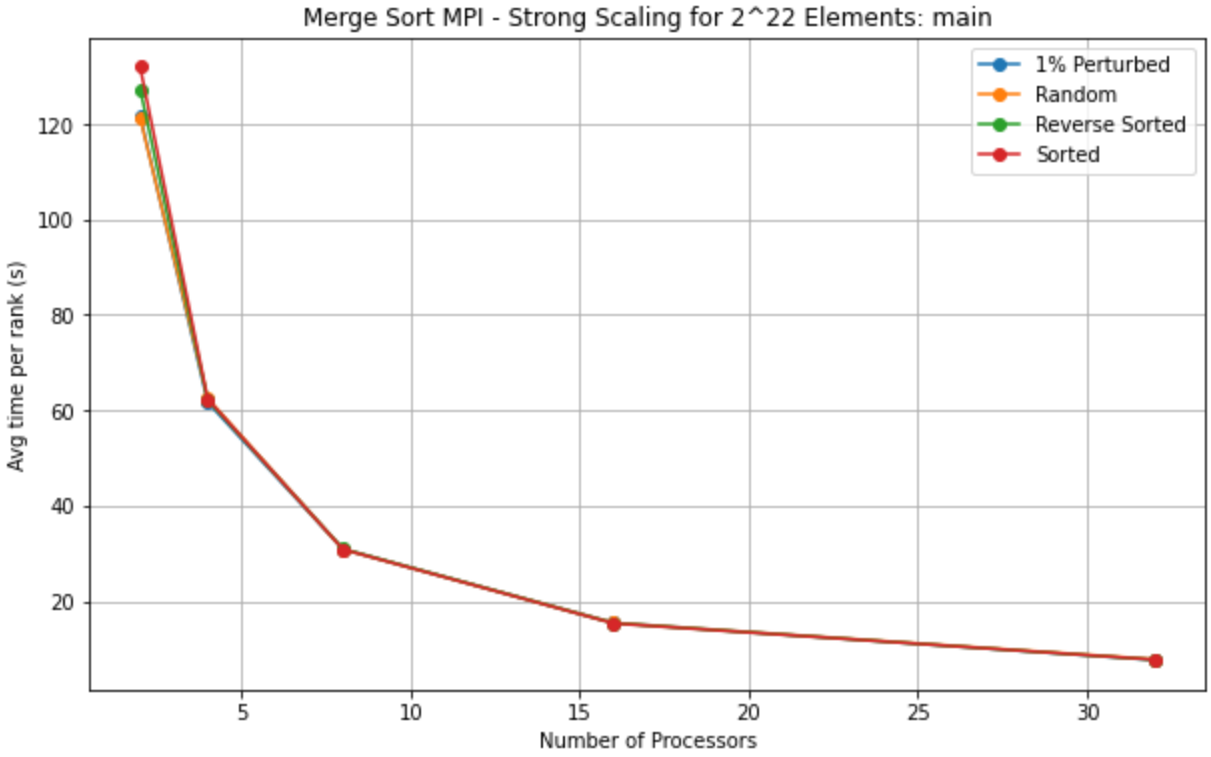
```
4  thickets created...
{'1% Perturbed': <thicket.thicket.Thicket object at 0x2b270690f7f0>, 'Random': <thick
et.thicket.Thicket object at 0x2b27054a1c70>, 'Reverse Sorted': <thicket.thicket.Thic
ket object at 0x2b2706521a60>, 'Sorted': <thicket.thicket.Thicket object at 0x2b2706c
f20d0>}
```

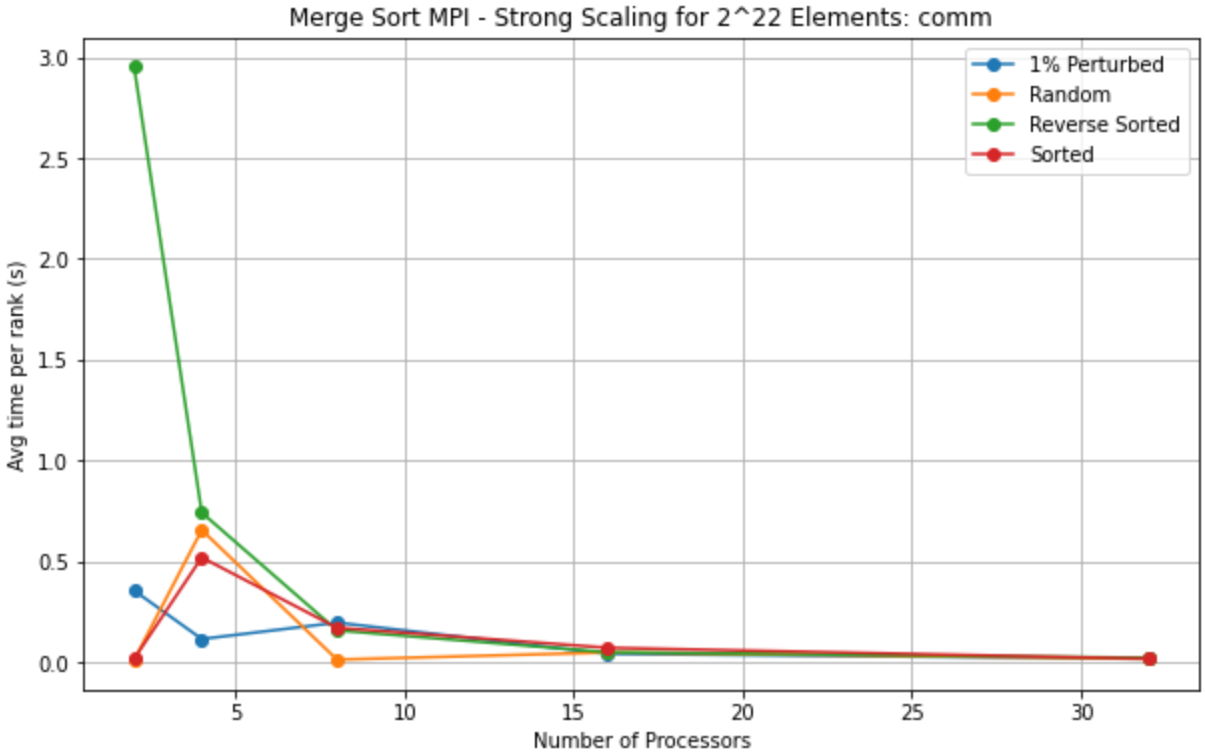
In [187…

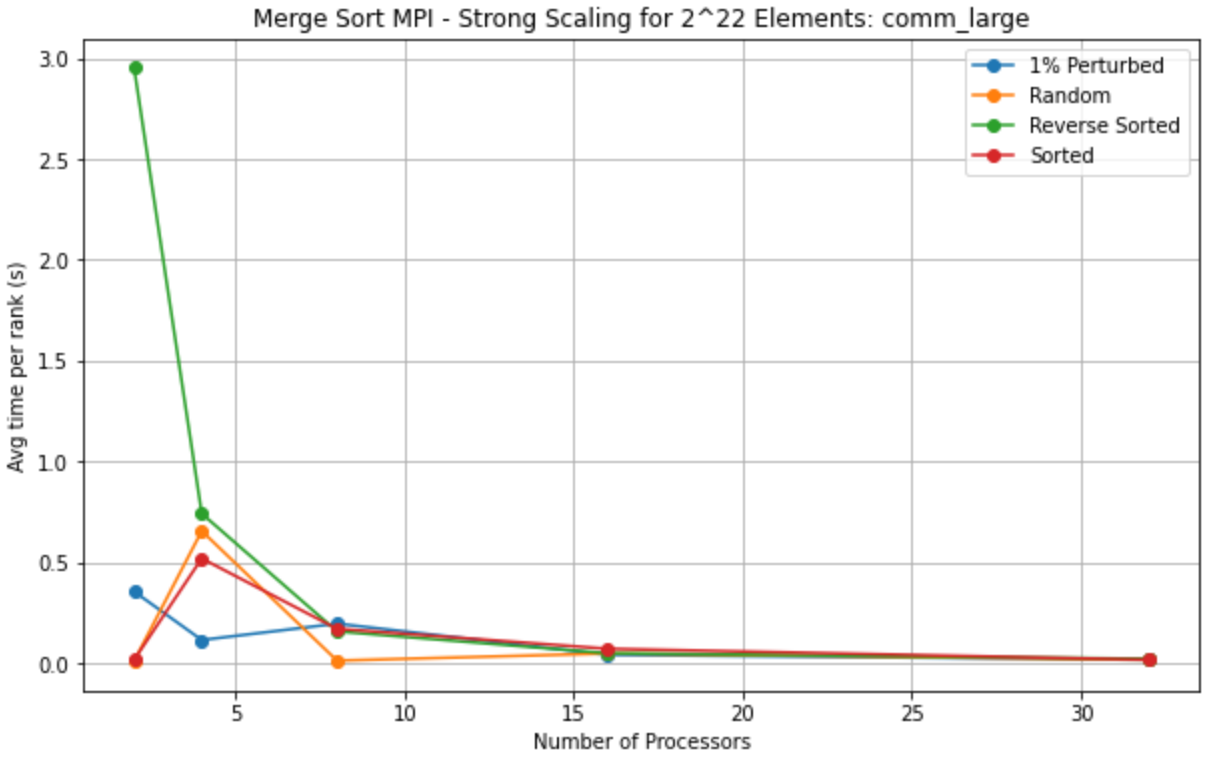
```
main = ctk22.dataframe.loc["main"]
comm = ctk22.dataframe.loc["comm"]
comm_large = ctk22.dataframe.loc["comm_large"]
MPI_Gather = ctk22.dataframe.loc["MPI_Gather"]
MPI_Scatter = ctk22.dataframe.loc["MPI_Scatter"]
comp = ctk22.dataframe.loc["comp"]
comp_large = ctk22.dataframe.loc["comp_large"]
comp_small = ctk22.dataframe.loc["comp_small"]
correctness_check = ctk22.dataframe.loc["correctness_check"]
data_init = ctk22.dataframe.loc["data_init"]

regions = [main, comm, comm_large, MPI_Gather, MPI_Scatter, comp, comp_large, comp_sma
names = ["main", "comm", "comm_large", "MPI_Gather", "MPI_Scatter", "comp", "comp_larg
```

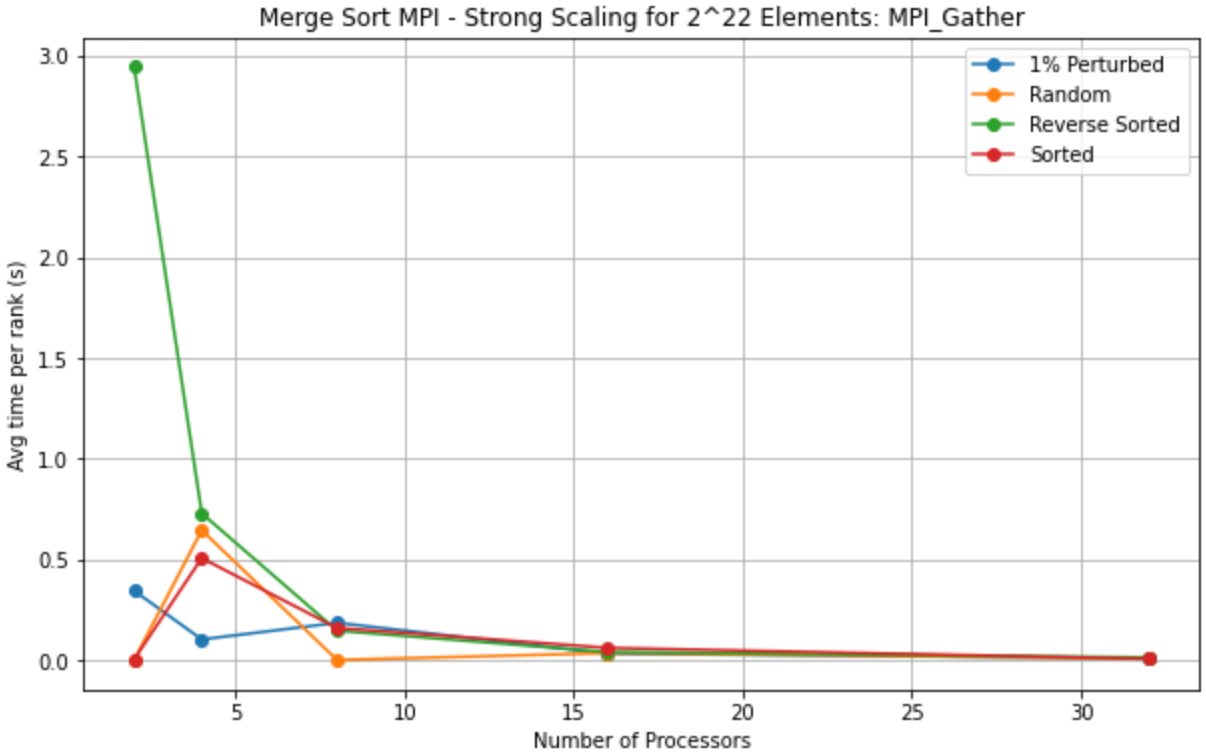
In [188…

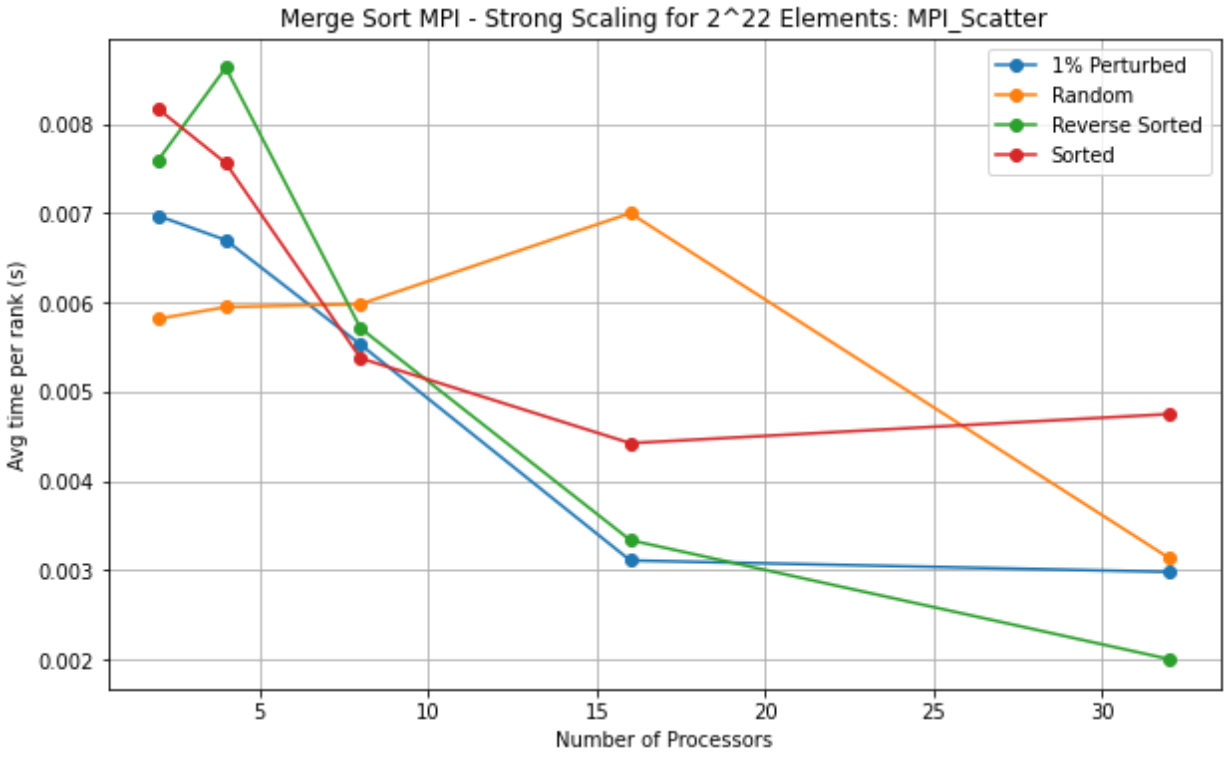
```
for region, name in zip(regions, names):
    plt.figure(figsize=(10, 6))  # Adjust the figure size if needed
    legend_labels = []
    for column in region.columns:
        first_index = column[0]  # Extract the first index
        legend_labels.append(first_index)
        plt.plot(region.index, region.xs(column, axis=1), marker='o', label=column)

    plt.xlabel('Number of Processors')
    plt.ylabel('Avg time per rank (s)')
    plt.title(f'Merge Sort MPI - Strong Scaling for 2^22 Elements: {name}')
    plt.legend(legend_labels)
    plt.grid(True)
    plt.show()
```

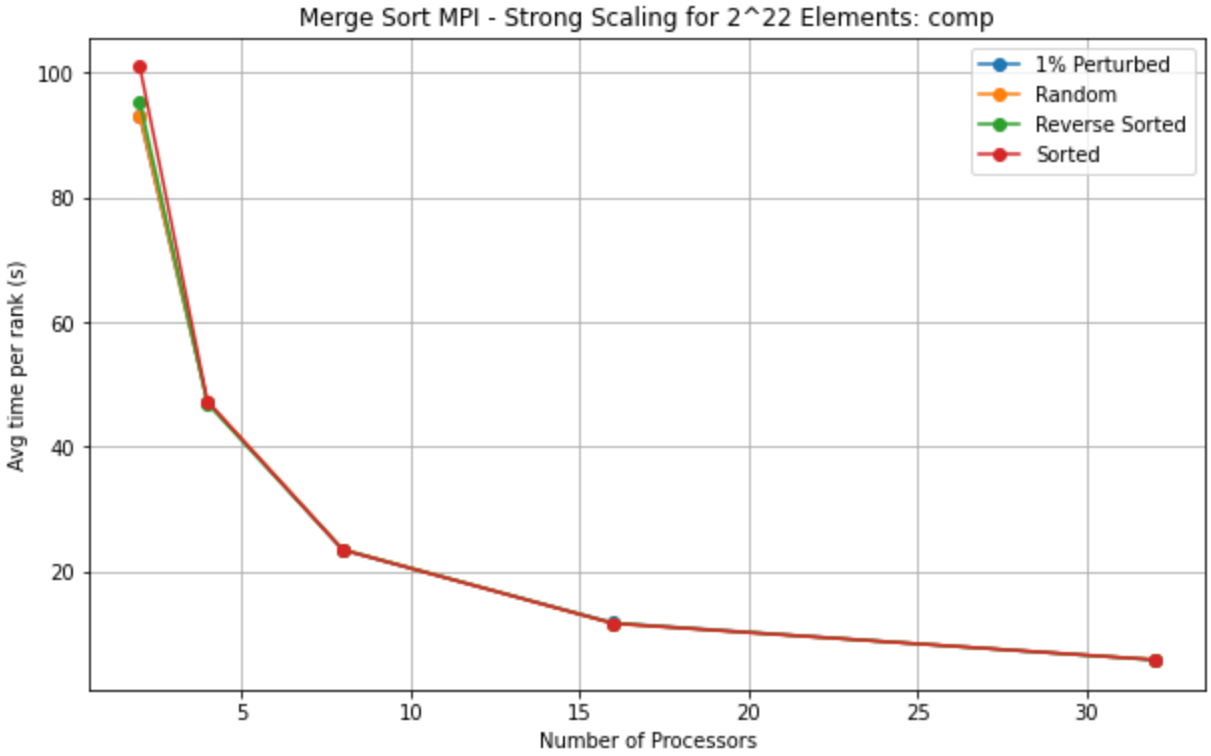


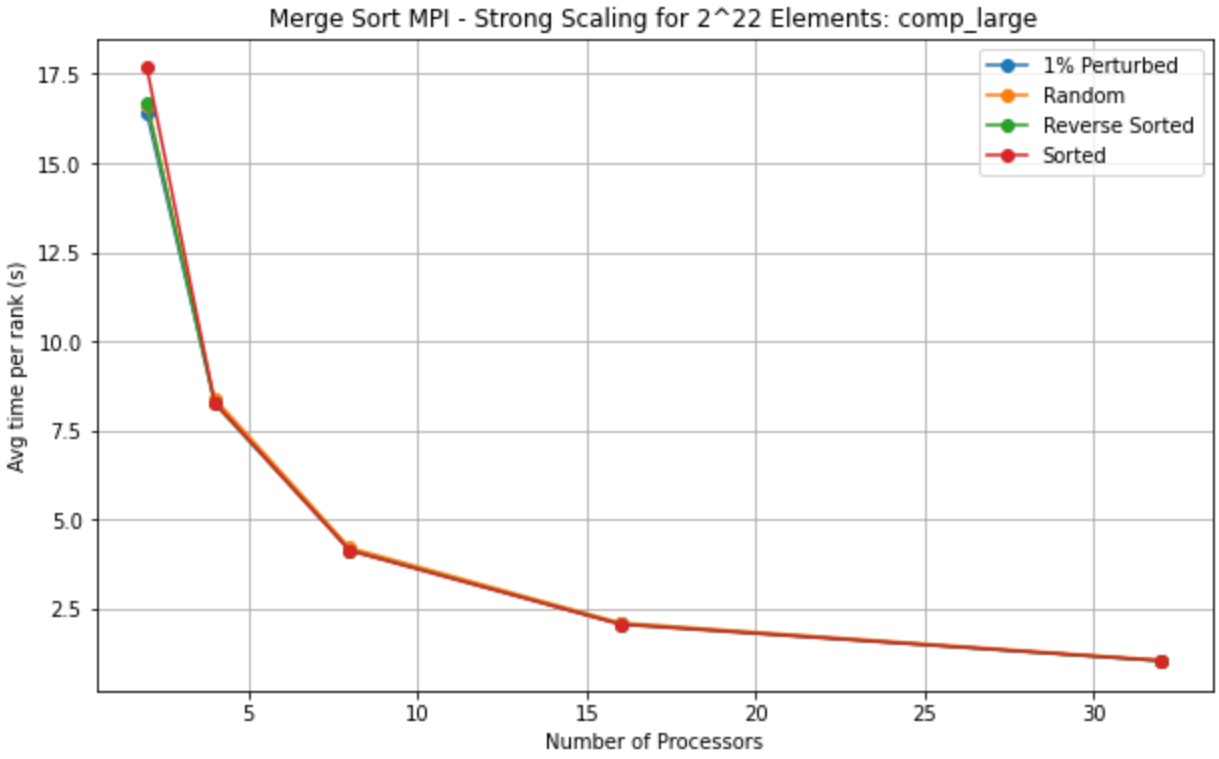

Merge Sort MPI - Strong Scaling for 2^22 Elements: comm
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
0.0
0.5
1.0
1.5
2.0
2.5
3.0
5
10
15
20
25
30

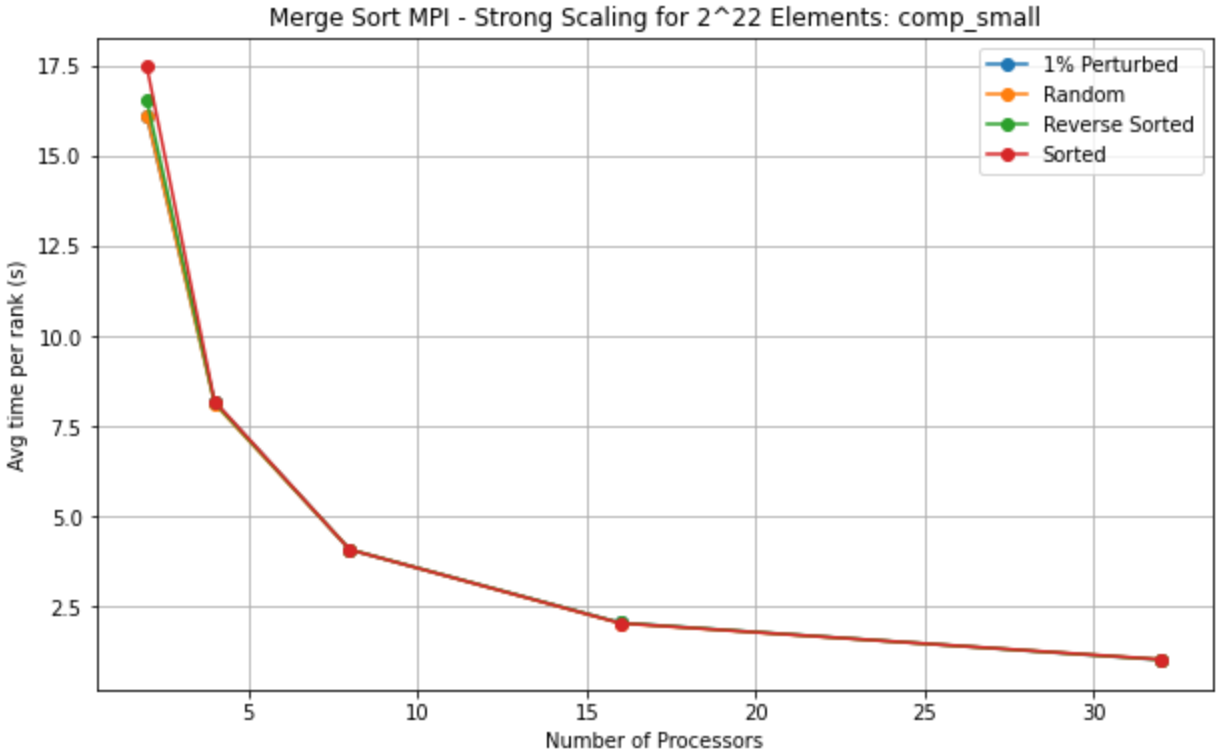

Merge Sort MPI - Strong Scaling for 2^22 Elements: comm_large
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
0.0
0.5
1.0
1.5
2.0
2.5
3.0
5
10
15
20
25
30

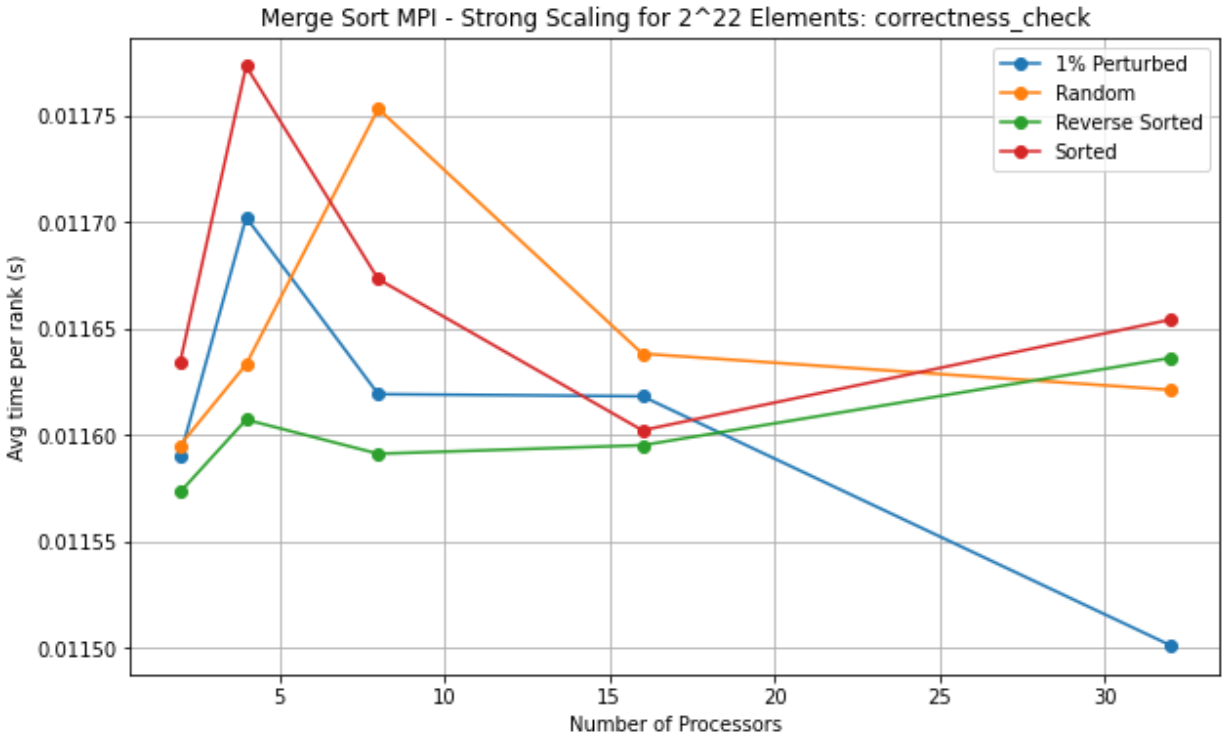

Merge Sort MPI - Strong Scaling for 2^22 Elements: MPI_Gather
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
3.0
2.5
2.0
1.5
1.0
0.5
0.0
5
10
15
20
25
30

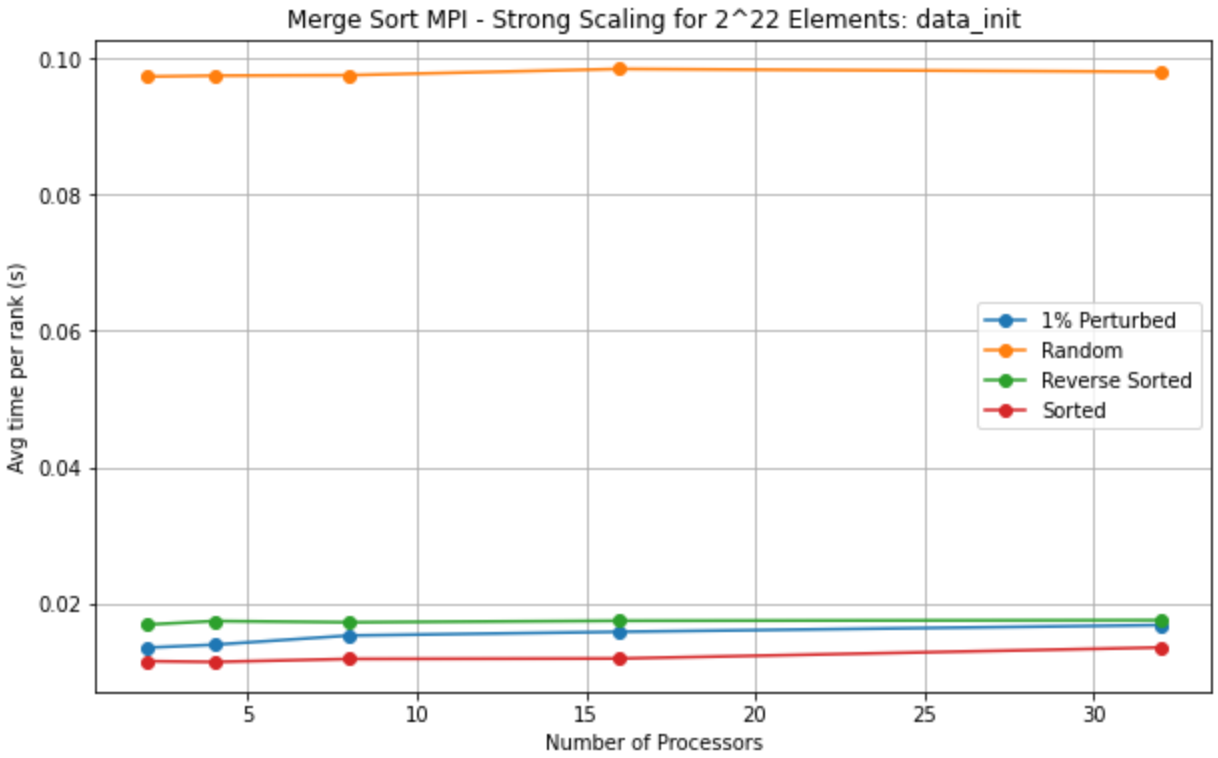

Merge Sort MPI - Strong Scaling for 2^22 Elements: MPI_Scatter
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
0.008
0.007
0.006
0.005
0.004
0.003
0.002
5
10
15
20
25
30


Merge Sort MPI - Strong Scaling for 2^22 Elements: comp
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
100
80
60
40
20
5
10
15
20
25
30


Merge Sort MPI - Strong Scaling for 2^22 Elements: comp_large
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
17.5
15.0
12.5
10.0
7.5
5.0
2.5
5
10
15
20
25
30


Merge Sort MPI - Strong Scaling for 2^22 Elements: comp_small
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
17.5
15.0
12.5
10.0
7.5
5.0
2.5
5
10
15
20
25
30


Merge Sort MPI - Strong Scaling for 2^22 Elements: correctness_check
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
0.01175
0.01170
0.01165
0.01160
0.01155
0.01150
5
10
15
20
25
30



2^24

In [189…

```
tk24 = th.Thicket.from_caliperreader(glob("cali_data_missingLast2ArraySizes/*16777216*
tk24.metadata
```

Out[189]:

profile	cali.caliper.version	mpi.world.size	spot.metrics	spot.tir
157546908	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
455601184	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
556558816	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
1041590045	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
1507035596	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
1822939741	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
2352590581	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
2771247297	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
2839794099	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
3014968345	2.11.0-dev	2	min#inclusive#sum#time.duration,max#inclusive#...	
3052917562	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
3136126191	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
3141781976	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	
3211190891	2.11.0-dev	8	min#inclusive#sum#time.duration,max#inclusive#...	
3238727412	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	

profile	cali.caliper.version	mpi.world.size	spot.metrics	spot.tir
3379288521	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
3553586603	2.11.0-dev	4	min#inclusive#sum#time.duration,max#inclusive#...	
3747016418	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
3860504276	2.11.0-dev	32	min#inclusive#sum#time.duration,max#inclusive#...	
4273443977	2.11.0-dev	16	min#inclusive#sum#time.duration,max#inclusive#...	

In [190…

```
gb24 = tk24.groupby("InputType")

ctk24 = th.Thicket.concat_thickets(
    thickets=list(gb24.values()),
    headers=list(gb24.keys()),
    axis='columns',
    metadata_key='num_procs'
)

ctk24.dataframe = ctk24.dataframe.reset_index().drop([("node", ""), ('1% Perturbed', '
                                                      ('Random', "nid"), ('Random', "s
                                                      ('Reverse Sorted', "nid"), ('Rev
                                                      ('Sorted', "nid"), ('Sorted', "s
                                                     ], axis=1)
ctk24.dataframe = ctk24.dataframe.rename({("name", ""): "name", ("num_procs", ""): "nu
```

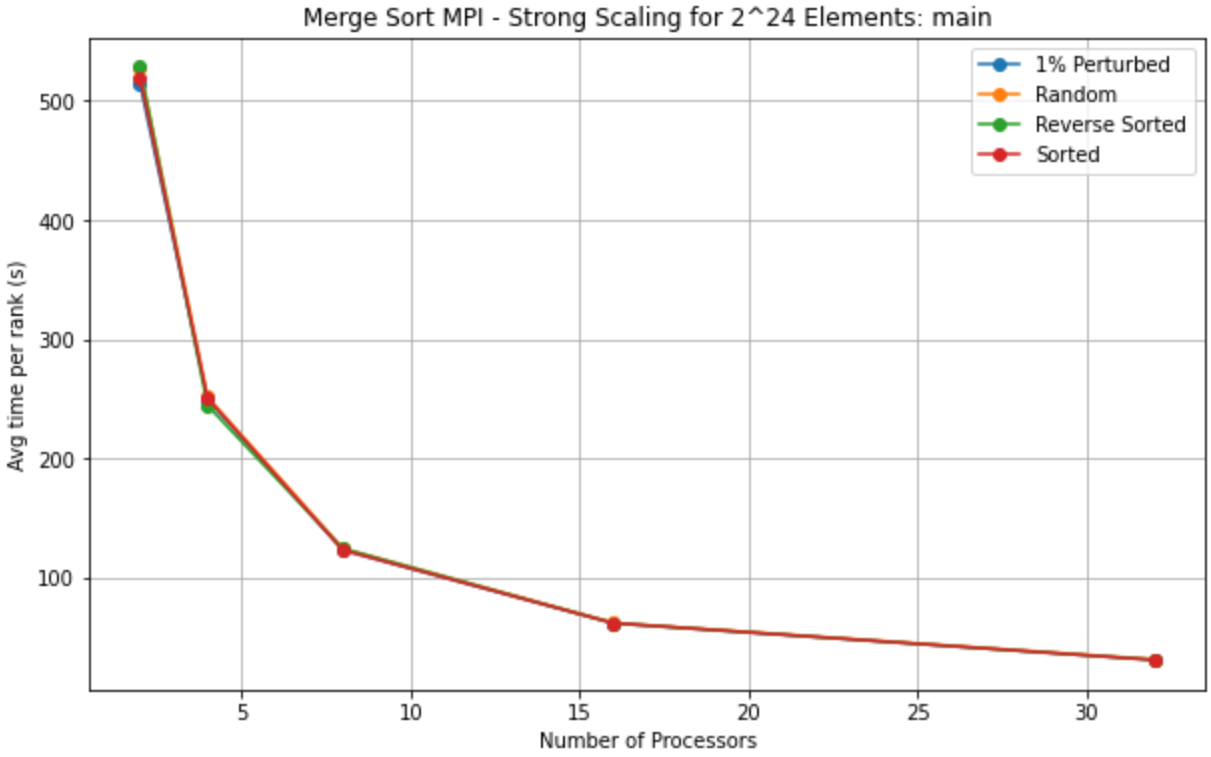
```
4  thickets created...
{'1% Perturbed': <thicket.thicket.Thicket object at 0x2b27065097c0>, 'Random': <thick
et.thicket.Thicket object at 0x2b2706bfc910>, 'Reverse Sorted': <thicket.thicket.Thic
ket object at 0x2b270528e190>, 'Sorted': <thicket.thicket.Thicket object at 0x2b27052
19b20>}
```

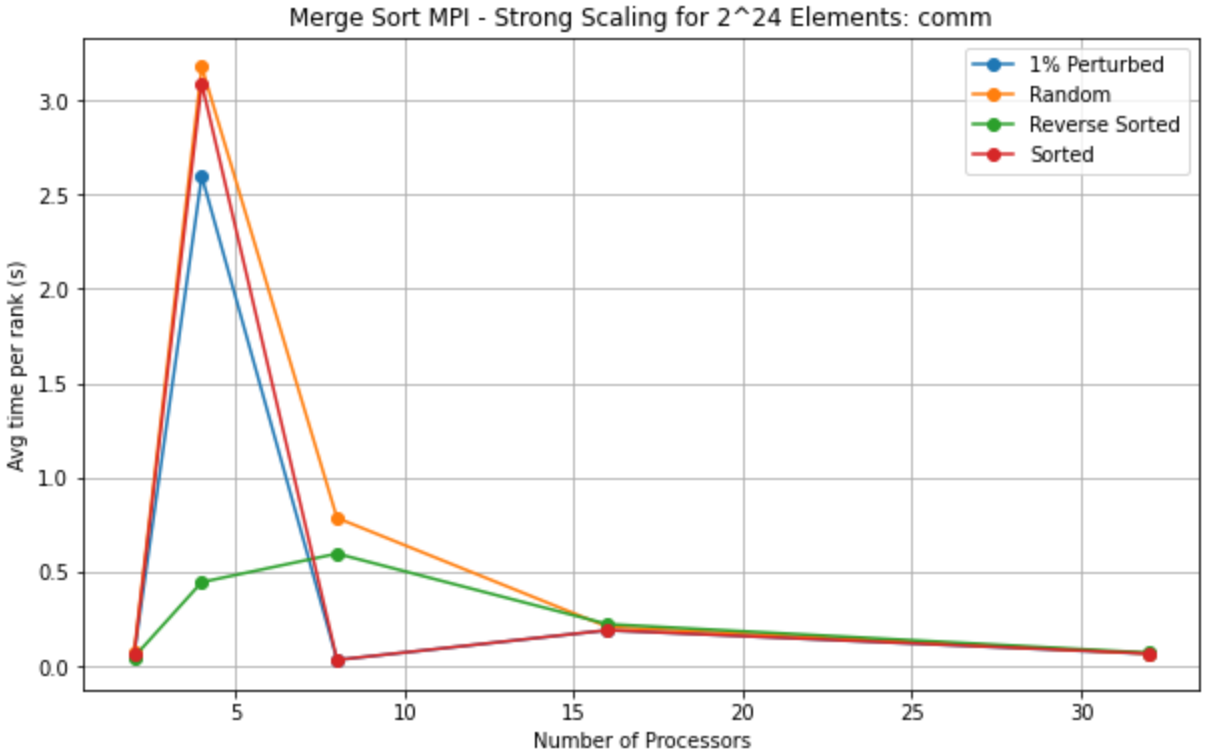
In [191…

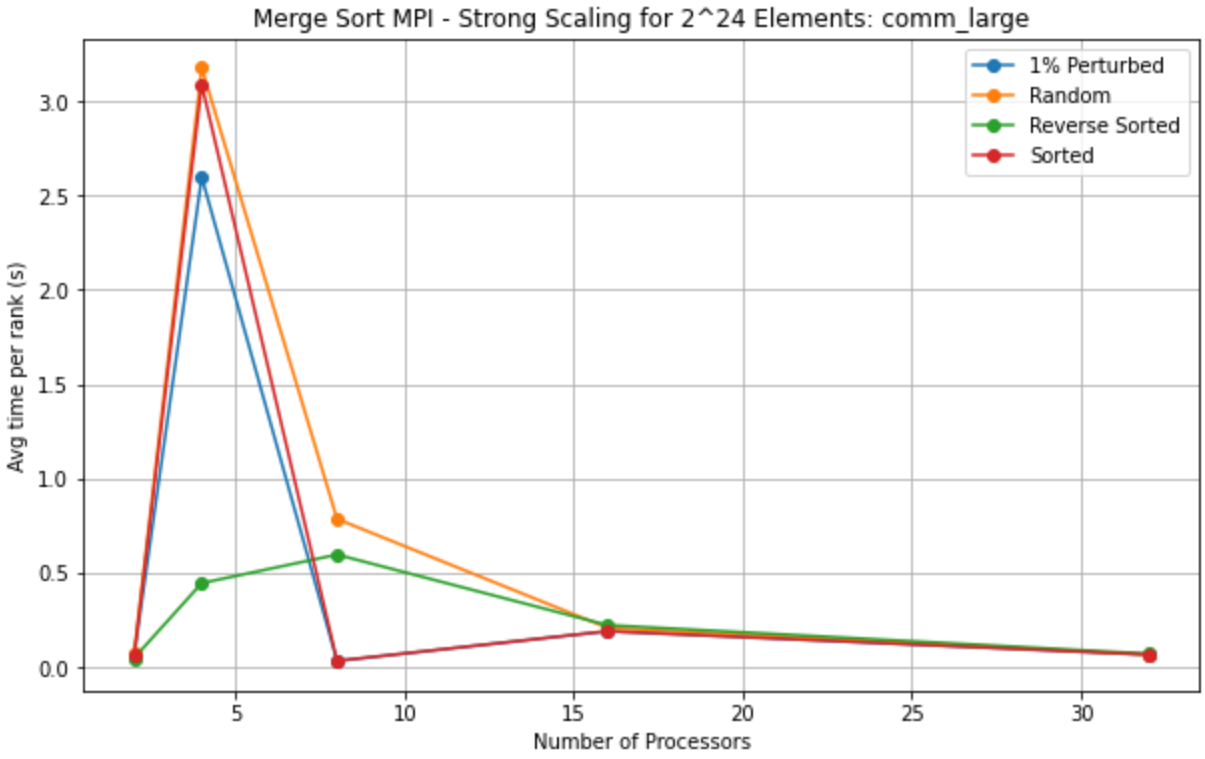
```
main = ctk24.dataframe.loc["main"]
comm = ctk24.dataframe.loc["comm"]
comm_large = ctk24.dataframe.loc["comm_large"]
MPI_Gather = ctk24.dataframe.loc["MPI_Gather"]
MPI_Scatter = ctk24.dataframe.loc["MPI_Scatter"]
comp = ctk24.dataframe.loc["comp"]
comp_large = ctk24.dataframe.loc["comp_large"]
comp_small = ctk24.dataframe.loc["comp_small"]
correctness_check = ctk24.dataframe.loc["correctness_check"]
data_init = ctk24.dataframe.loc["data_init"]

regions = [main, comm, comm_large, MPI_Gather, MPI_Scatter, comp, comp_large, comp_sma
names = ["main", "comm", "comm_large", "MPI_Gather", "MPI_Scatter", "comp", "comp_larg
```

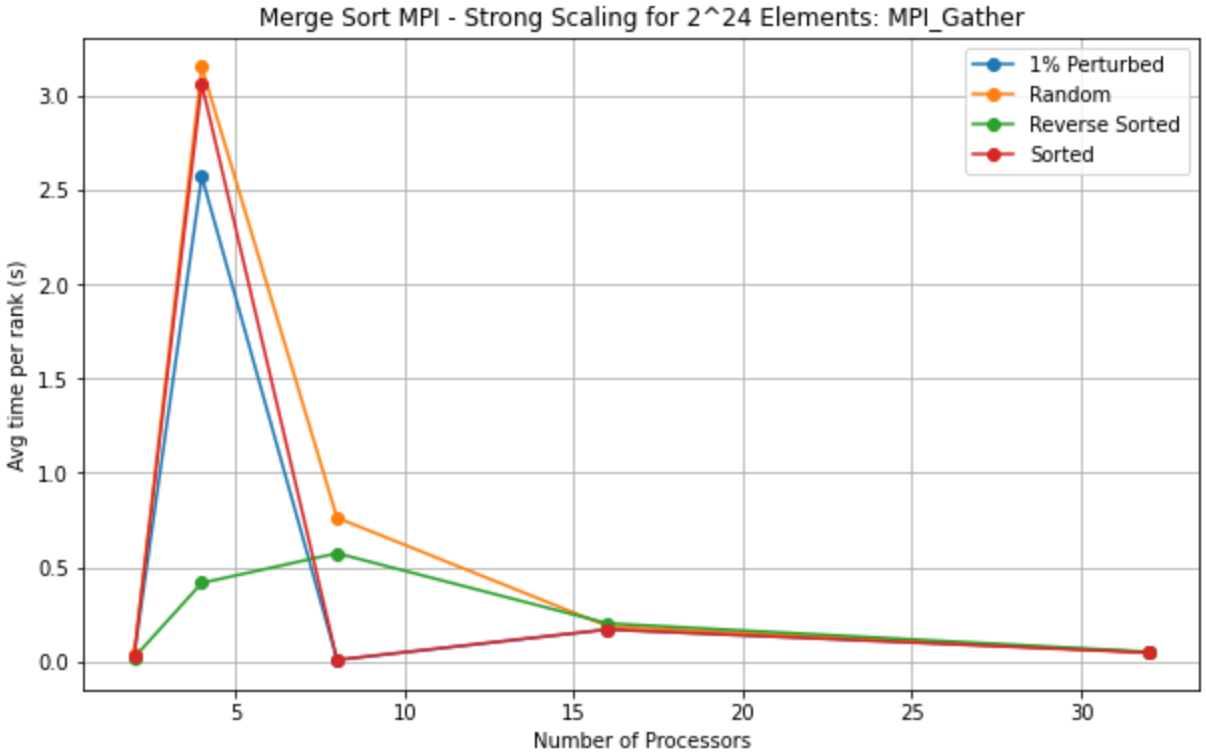
In [192…

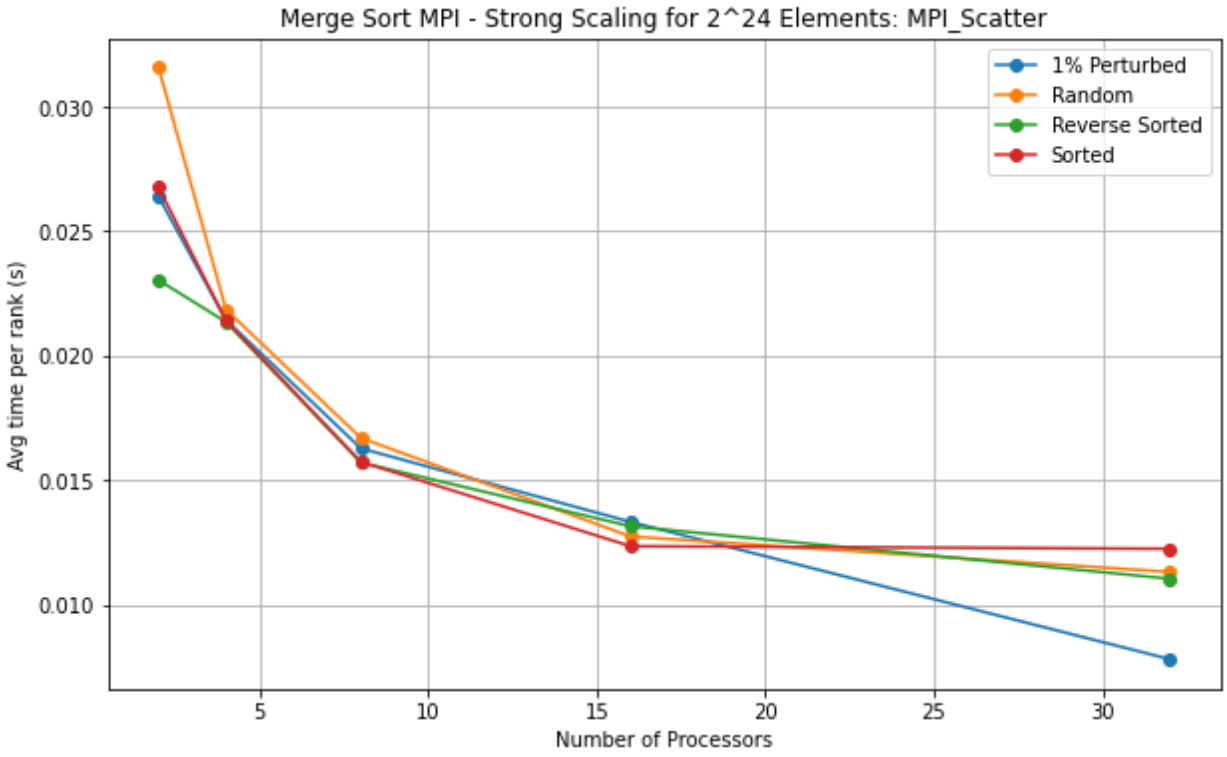
```
for region, name in zip(regions, names):
    plt.figure(figsize=(10, 6))  # Adjust the figure size if needed
    legend_labels = []
    for column in region.columns:
        first_index = column[0]  # Extract the first index
        legend_labels.append(first_index)
        plt.plot(region.index, region.xs(column, axis=1), marker='o', label=column)

    plt.xlabel('Number of Processors')
    plt.ylabel('Avg time per rank (s)')
    plt.title(f'Merge Sort MPI - Strong Scaling for 2^24 Elements: {name}')
    plt.legend(legend_labels)
    plt.grid(True)
    plt.show()
```

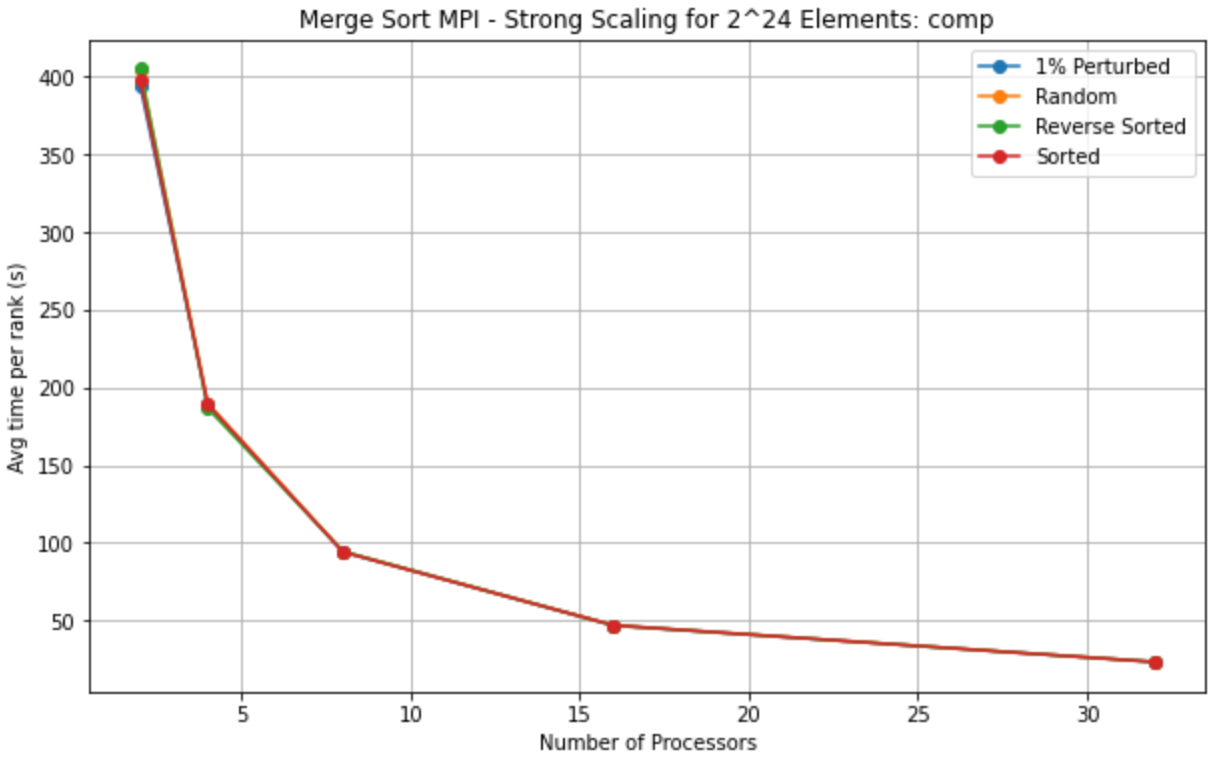


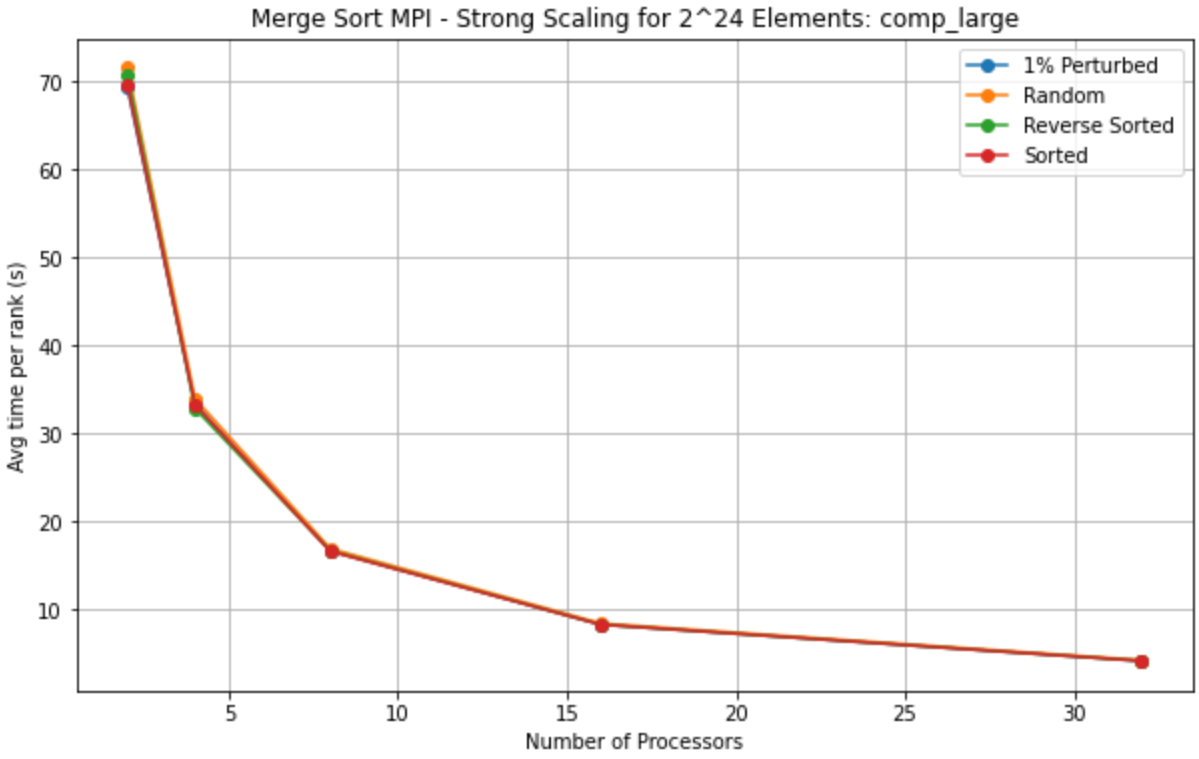

Merge Sort MPI - Strong Scaling for 2^24 Elements: comm
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
0.0
0.5
1.0
1.5
2.0
2.5
3.0
5
10
15
20
25
30

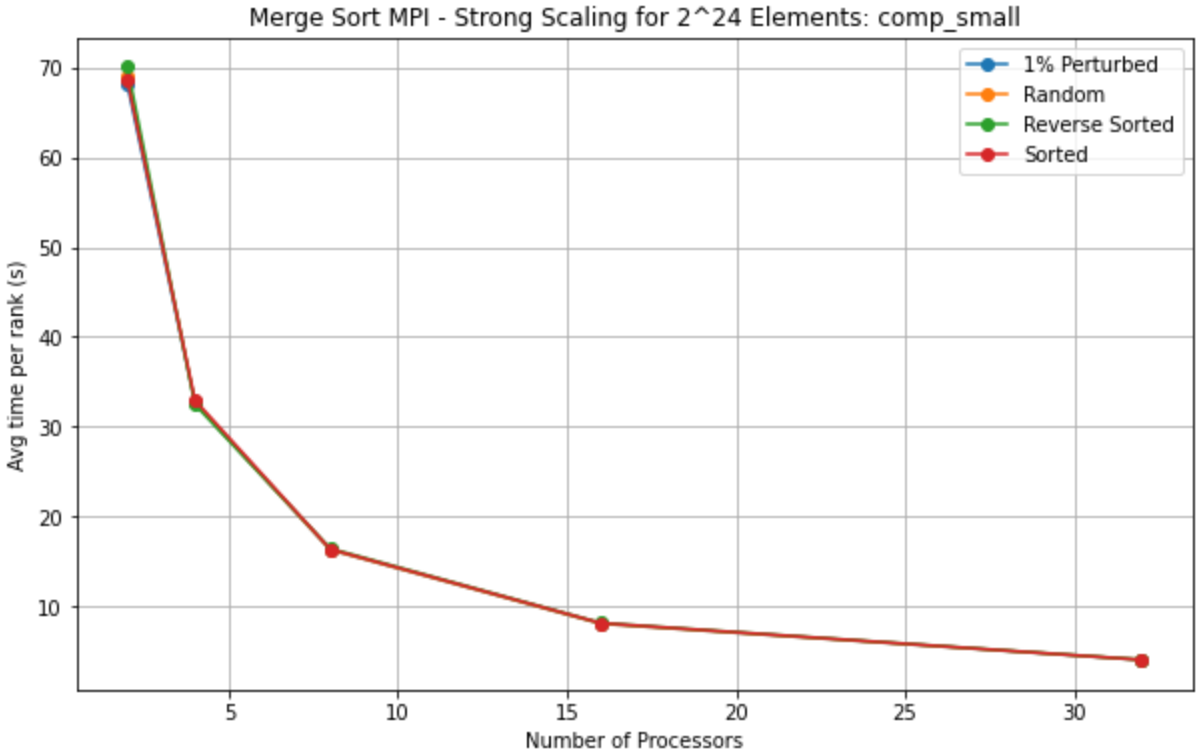

Merge Sort MPI - Strong Scaling for 2^24 Elements: comm_large
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
0.0
0.5
1.0
1.5
2.0
2.5
3.0
5
10
15
20
25
30

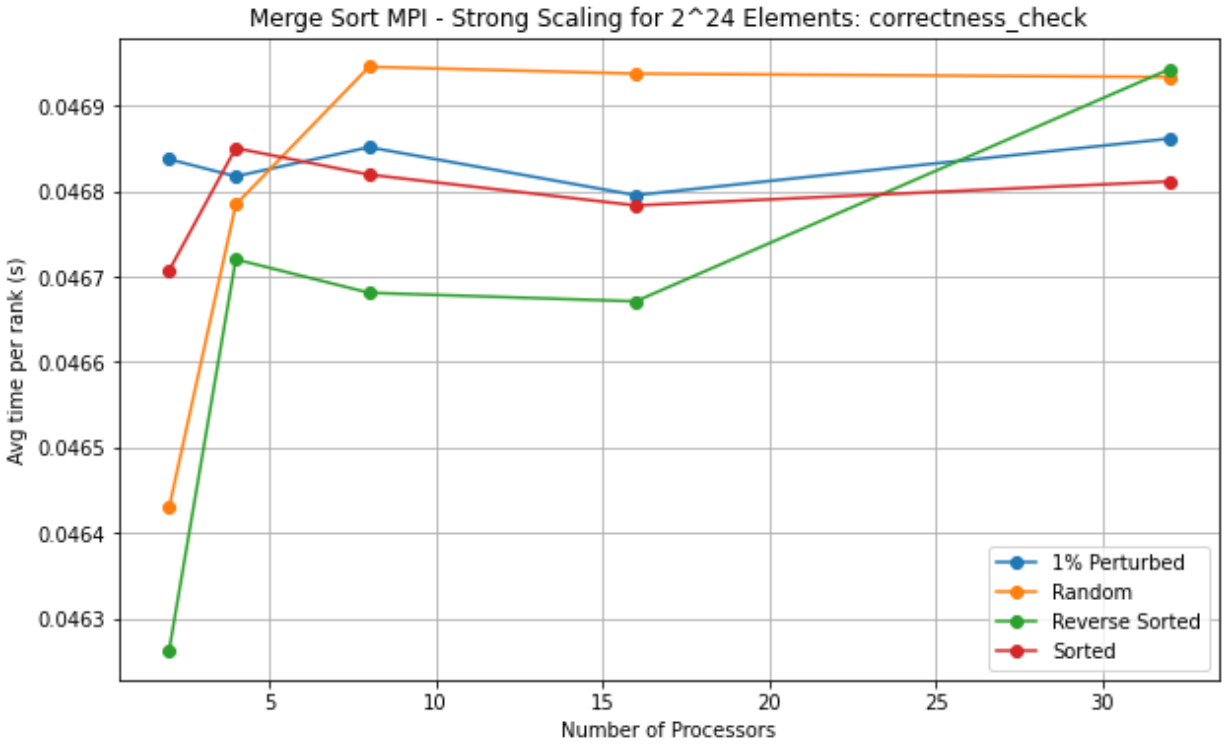

Merge Sort MPI - Strong Scaling for 2^24 Elements: MPI_Gather
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
0.0
0.5
1.0
1.5
2.0
2.5
3.0
5
10
15
20
25
30

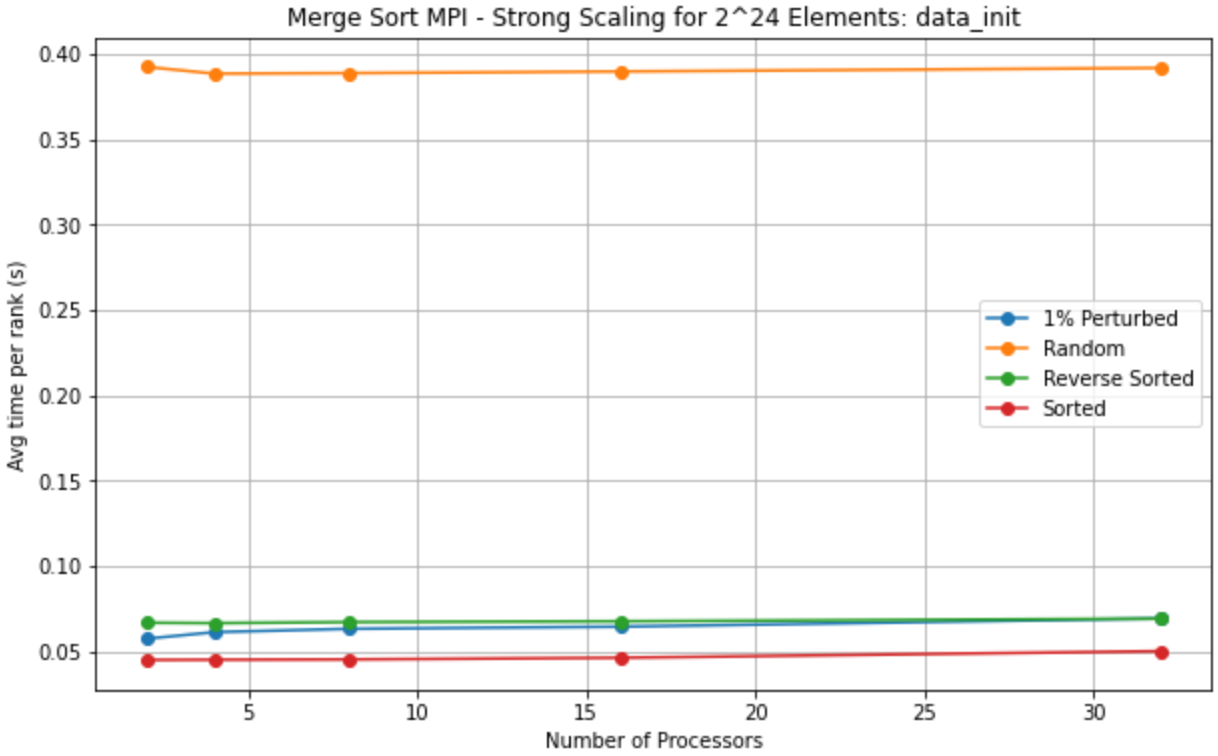

Merge Sort MPI - Strong Scaling for 2^24 Elements: MPI_Scatter
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
0.010
0.015
0.020
0.025
0.030
5
10
15
20
25
30


Merge Sort MPI - Strong Scaling for 2^24 Elements: comp
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
400
350
300
250
200
150
100
50
5
10
15
20
25
30


Merge Sort MPI - Strong Scaling for 2^24 Elements: comp_large
1% Perturbed
Random
Reverse Sorted
Sorted
Avg time per rank (s)
Number of Processors
70
60
50
40
30
20
10
5
10
15
20
25
30


Merge Sort MPI - Strong Scaling for 2^24 Elements: comp_small
Avg time per rank (s)
Number of Processors
1% Perturbed
Random
Reverse Sorted
Sorted


Merge Sort MPI - Strong Scaling for 2^24 Elements: correctness_check
Avg time per rank (s)
Number of Processors
1% Perturbed
Random
Reverse Sorted
Sorted


Merge Sort MPI - Strong Scaling for 2^24 Elements: data_init
Avg time per rank (s)
Number of Processors
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
5
10
15
20
25
30
1% Perturbed
Random
Reverse Sorted
Sorted

In [ ]: