



**National University**  
of computer and emerging sciences

## **Project Report**

### **CS3006 Parallel and Distributed Computing**

#### **Project Title**

Comparison of Serial and Parallel Sorting of Records in a Large Dataset

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# Comparison between Process And Threads

## Introduction

Our application allows the user to sort a large dataset of student records on the basis of any attribute they choose. We have developed two separate versions of the application, one is a serial version and the other is a parallel version, we also compared the applications to analyse the time taken for different sizes of the dataset, using a graph.

## Methodology

First we run the **generatecsv.py** and give the N row size of the csv file and it will create a csv file with our defined attributes, we won't actually be running this file since we would need to create multiple large files which would be costly so we have created some files already and stored them in the **datasets** folder which we will be using.

The project can be executed in 2 different ways, we could either run it through the shellscript **runall.sh** which automates (and doesn't take any user input) the process of running both serial and parallel versions of our application on various datasets of different sizes then records the time taken for each and plots a graph to show the results

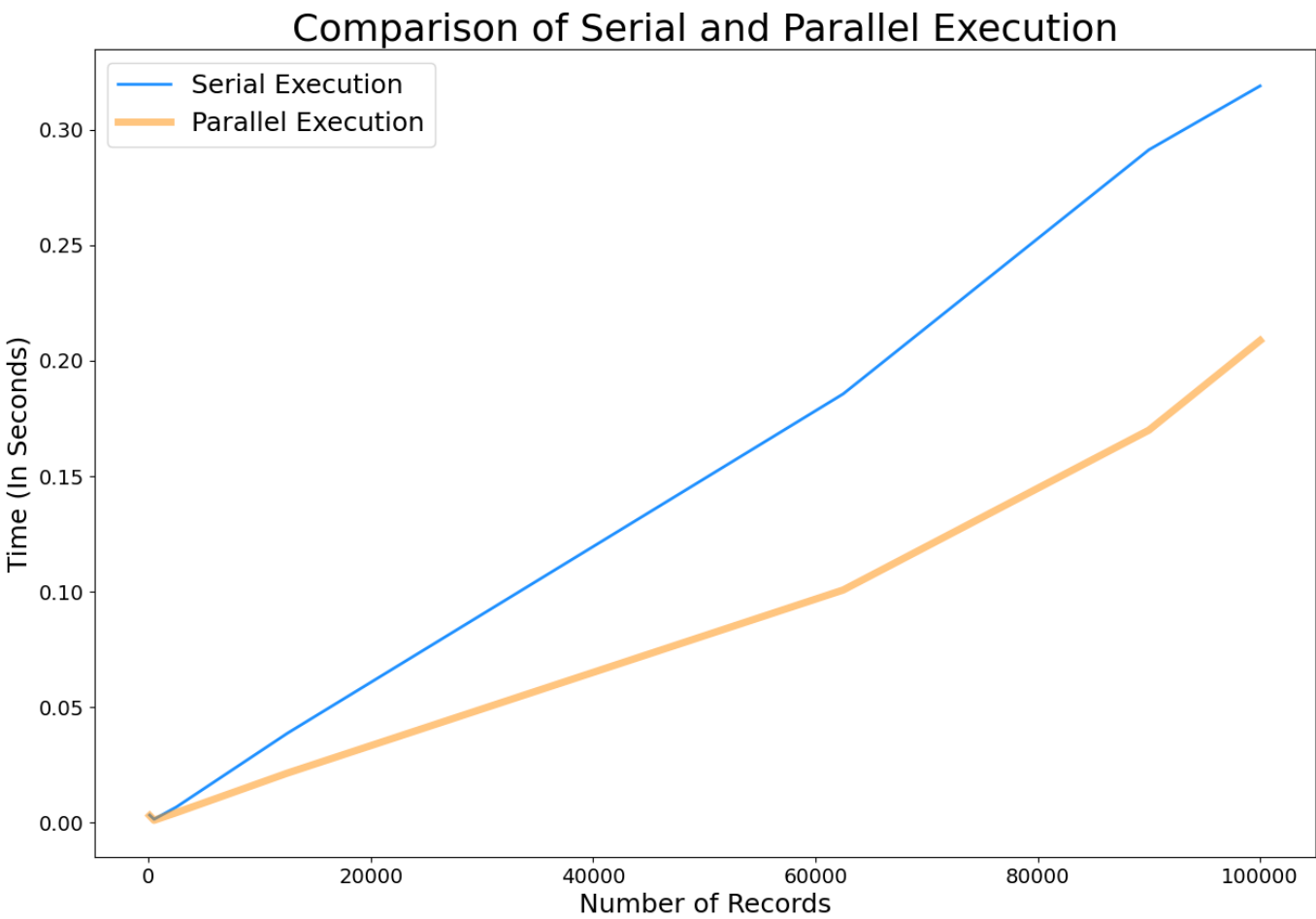
Alternatively we could run each program separately through the command line which would give us the time taken for the whole application to run on a single dataset (whose path we would hardcode near the top of the sortcsv.cpp file in the variable FILEPATH) as well as the time taken for each thread and the chunk allocated to each thread.

For the serial version, we used mergesort to sort the data on the basis of a user selected attribute, and for the parallel version we used the OpenMP API to parallelise the mergesort algorithm with the help of **#pragma omp task**, which allows us to easily implement parallelism in recursive code and then we used shell scripting to automate the process of running both the parallel and serial versions of the application on a range of datasets, and it stores the time required to run each algorithm for each file in a csv file, after the algorithm is run on the range of datasets, the csv file is used by a Python program to generate a line graph for both versions of the applications. This graph can be observed more accurately at runtime but an image of this graph can be seen in this report.

**Code on Github** 

The project can be [viewed on Github](https://github.com/AhmedMahmood19/pdc-project)  
[\[https://github.com/AhmedMahmood19/pdc-project\]](https://github.com/AhmedMahmood19/pdc-project)

# Graph



# Results

The results we would achieve by running our program from **runall.sh** is that it will sort some pre-made datasets of varying sizes in serial and also in parallel, record their execution time and run **graph.py** to plot a line graph of (number of records) against (execution time) for both serial and parallel execution, which is shown above.

Alternatively by running our serial and parallel programs from the command line it will allow us to choose an attribute, on the basis of which the data will be sorted, then it displays the runtime in the terminal and it also creates the sorted csv file in the **scripts** folder but only in the parallel application do we also get a thread log(which shows which thread was allocated which chunk of data and how long it took to operate on it) which is stored in the **parallel** folder.

**Dataset containing 100,000 records before sorting:**

	A	B	C	D	E	F	G	H
1	Student ID	First Name	Last Name	CNIC	Email	Phone Number	Credit Hours	CGPA
2	11K-9001	Karina	Smith	36243-5068765-8	matthew04@gmail.com	+92 5661492883	38	3.9
3	07K-4734	Andre	Rodriguez	98575-2143558-7	john53@gmail.com	+92 4662795290	58	2.19
4	11K-1540	Kimberly	Wells	38001-8212432-8	andrewortiz@gmail.com	+92 6998976524	74	2.78
5	15K-8372	Russell	Kennedy	81159-1003102-3	troy78@gmail.com	+92 1078372269	21	2.99
6	49K-4969	Sandra	Rice	22842-0370638-7	david33@gmail.com	+92 3892232299	31	2.37
7	99K-5237	Connie	Watson	89455-4410799-1	luisreed@gmail.com	+92 8581211820	91	2.92
8	82K-7351	Chelsea	Thomas	71496-7464787-9	andrewfreeman@gmail.com	+92 0791776010	19	2.12
9	95K-2844	Eddie	Duarte	82527-5237829-5	donna04@gmail.com	+92 5900603801	39	2.4
10	83K-0923	Sandra	Petersen	14655-3890425-0	mercerleslie@gmail.com	+92 3188221465	115	2.56
11	72K-5282	Joel	Hines	87085-9294723-2	parkdeanna@gmail.com	+92 9320145771	33	2.82
12	22K-8217	Rebecca	Aguilar	73150-3841382-4	smithpaul@gmail.com	+92 5644265177	25	3.49
13	35K-7047	Kaylee	Ryan	45251-2765541-2	uvasquez@gmail.com	+92 9042048880	20	2.77
14	79K-7457	Bonnie	Martinez	34184-6211470-1	oscar02@gmail.com	+92 2976420174	75	3.8
15	65K-1698	Betty	Yoder	96985-9572769-8	aaronfoster@gmail.com	+92 9690823038	117	3.35
16	58K-9966	Daniel	Williams	34032-0182363-9	ojones@gmail.com	+92 3846134808	100	2
17	59K-7287	Paul	Holland	58973-0071289-7	tsellers@gmail.com	+92 3870657886	64	2.31
18	97K-7408	Michael	Mccoy	65822-4432347-2	joannaparsons@gmail.com	+92 1982718955	65	3.6
19	51K-2454	Tina	Garner	98945-8880973-9	alexanderbenjamin@gmail.com	+92 4394061158	52	2.74
20	26K-0467	Sandra	Haynes	99810-9848062-8	jordanjeffrey@gmail.com	+92 4589492689	29	2.69
21	32K-8904	Thomas	Parks	28153-5276659-7	kevin43@gmail.com	+92 3923296430	86	2.59
22	45K-7454	Michael	Bell	19748-2255489-8	jamesmichael@gmail.com	+92 2387971890	64	2.59
23	93K-9244	Kristina	Bailey	28599-7237174-5	dperkins@gmail.com	+92 0990887874	71	2.66
24	04K-2031	Matthew	Campbell	26789-1039645-2	shawnellott@gmail.com	+92 0015551895	34	3.82
25	20K-6597	Timothy	Joseph	77721-8785367-2	evansjason@gmail.com	+92 2233770407	49	3.23
26	86K-4741	Michael	Ashley	52223-7347751-3	hjohnson@gmail.com	+92 0211034587	130	3.69
27	82K-6413	Derek	Davis	54204-3792879-2	tnunez@gmail.com	+92 2034790644	97	3.13
28	72K-1887	Anna	Compton	60697-4881215-0	dorseysamuel@gmail.com	+92 1159466123	99	2.35
29	00K-6076	David	Lambert	71046-8396905-9	ann50@gmail.com	+92 0956889073	53	2.54
30	03K-6267	Ryan	Anderson	61976-6287984-7	imitchell@gmail.com	+92 6706728233	37	3.28
31	58K-3534	Kathy	Webb	57220-8028430-0	andrew25@gmail.com	+92 3219569290	114	2.63
32	48K-8576	Elizabeth	Edwards	80186-2809392-4	csnyder@gmail.com	+92 1665058679	122	2.6
33	93K-1657	Elizabeth	Johnson	38429-4774399-3	lisagreen@gmail.com	+92 2683783984	60	2.69
34	29K-3153	Jessica	Perez	42235-7161888-7	april99@gmail.com	+92 9186149379	92	3.27
35	32K-7248	Joseph	Jensen	25026-3079462-9	parkerbrett@gmail.com	+92 8003962384	47	2.1
36	33K-1992	Carly	West	31365-0075452-0	jacobthompson@gmail.com	+92 5141200881	76	3.67
37	34K-6096	Stephen	Holmes	99463-1864468-3	donna36@gmail.com	+92 4748267917	95	3.26
38	42K-2985	Brittany	Weeks	97880-4838761-9	msantos@gmail.com	+92 7881393418	84	2.79

The command line when running the serial application:

```
~/Repos/pdc-project | master ➤ cd serial
~/Repos/pdc-project/serial | master ➤ g++ sortcsv.cpp -o sortcsv.out
~/Repos/pdc-project/serial | master !2 ➤ ./sortcsv.out
:::Choose the attribute to sort by, enter the corresponding option number:::

Option No. : Attribute

0          : Student ID
1          : First Name
2          : Last Name
3          : CNIC
4          : Email
5          : Phone Number
6          : Credit Hours
7          : CGPA

0
Time Taken: 0.277052%
```

The command line when running the parallel application:

```
~/Repos/pdc-project | master !2 ➤ cd parallel
~/Repos/pdc-project/parallel | master !2 ➤ g++ -fopenmp sortcsv.cpp -o sortcsv.out
~/Repos/pdc-project/parallel | master !2 ➤ ./sortcsv.out
:::Choose the attribute to sort by, enter the corresponding option number:::

Option No. : Attribute

0          : Student ID
1          : First Name
2          : Last Name
3          : CNIC
4          : Email
5          : Phone Number
6          : Credit Hours
7          : CGPA

0
Time Taken: 0.178455%
```



Dataset after sorting in serial(start and end of sorted file shown, please zoom in to see clearly):

Since we chose option 0 for both applications, it will sort on the basis of Student ID

1	Student ID	First Name	Last Name	CNIC	Email	Phone Number	Credit Hours	CGPA	99964	99K-9676	Cindy	Reed	74494-7279710-7	qsnyder@gmail.com	+92 5865685608	37	3.43
2	00K-0003	Joshua	Curtis	86913-2638977-2	loriballard@gmail.com	+92 3267714395	92	3.23	99965	99K-9682	Danielle	Bryant	74233-0673746-0	matthewadams@gmail.com	+92 7810597692	70	3.72
3	00K-0018	Joanna	Preston	16696-5325280-7	charles76@gmail.com	+92 6913000575	56	3.77	99966	99K-9683	Christopher	Wilson	78184-6268847-6	wkelley@gmail.com	+92 4141731119	69	2.37
4	00K-0025	Christian	Barker	53821-0252968-7	kaitlynkim@gmail.com	+92 2501995935	118	3.61	99967	99K-9687	Ronald	Cameron	70311-5625512-7	esilva@gmail.com	+92 9718373697	87	3.2
5	00K-0026	Jennifer	Roberts	83938-9522082-2	qlang@gmail.com	+92 8318694854	109	3.84	99968	99K-9691	John	Smith	90456-2664873-7	haley37@gmail.com	+92 8094893429	68	3.71
6	00K-0029	Katherine	Gomez	99721-9702287-0	powersheather@gmail.com	+92 2558579456	70	2.51	99969	99K-9695	Heather	Reilly	90564-6909426-3	gcooper@gmail.com	+92 5774207020	47	3.57
7	00K-0043	Sarah	Parsons	79038-9691638-9	rayryan@gmail.com	+92 6053638040	39	3.1	99970	99K-9697	Carla	Carter	45759-9212543-6	terrygarcia@gmail.com	+92 7726364671	124	3.71
8	00K-0051	Edward	Thomas	17571-4164701-0	morrowkevin@gmail.com	+92 7011578446	65	3.11	99971	99K-9701	Christina	Curtis	94503-8601745-3	paulporter@gmail.com	+92 7438690253	72	3.2
9	00K-0053	Alexis	Waters	99122-5384944-3	james55@gmail.com	+92 7888298849	103	3.19	99972	99K-9724	Mary	Suarez	24053-6165306-6	steven16@gmail.com	+92 3578810326	129	2
10	00K-0068	Nicholas	Frost	70498-7015299-7	andradeaustin@gmail.com	+92 9042444576	44	2.83	99973	99K-9725	Gary	Wong	24221-0189126-2	benjamin62@gmail.com	+92 9020724251	34	3.69
11	00K-0076	Timothy	Norris	96025-8464314-1	daniel81@gmail.com	+92 2883077758	104	3.95	99974	99K-9731	Cody	Adams	52169-2916245-0	kelleywilliam@gmail.com	+92 1810067571	108	2.62
12	00K-0082	Kathryn	Evans	10117-6854597-0	mbowman@gmail.com	+92 0045469336	111	3.1	99975	99K-9741	Lisa	Martinez	43804-2716422-6	christine32@gmail.com	+92 822255468	58	2.69
13	00K-0084	Robert	Bauer	69210-3004788-3	robert62@gmail.com	+92 0065934087	72	3.67	99976	99K-9743	Jeffery	Pham	19766-1852117-7	xryan@gmail.com	+92 4087230892	35	3.3
14	00K-0088	Cheryl	Ortiz	21023-2992469-6	brian20@gmail.com	+92 4728906086	53	3.96	99977	99K-9753	Jamie	Moreno	90733-1370396-8	vanessalynch@gmail.com	+92 5039227250	57	2.3
15	00K-0090	Donald	Delacruz	67967-2597381-5	hlopez@gmail.com	+92 6644873987	57	2.98	99978	99K-9763	Jennifer	Odom	26668-9482039-4	steverwilliams@gmail.com	+92 6058959793	45	3.49
16	00K-0124	Nicole	Shannon	86090-1932288-1	tfritz@gmail.com	+92 2138375934	72	3.34	99979	99K-9765	Gregory	Jacobson	88329-0558109-5	kevin64@gmail.com	+92 3763510274	66	3.27
17	00K-0129	Jennifer	Wilcox	81511-9575060-9	littledavid@gmail.com	+92 0922292379	47	2.22	99980	99K-9767	Adriana	Salazar	41486-0198108-1	jamesclark@gmail.com	+92 9116620205	68	3.93
18	00K-0131	Angela	Henry	89505-375552-4	sharonrivera@gmail.com	+92 3465302006	93	3.53	99981	99K-9769	James	Watson	24491-0790700-6	richardlutz@gmail.com	+92 3420556084	59	2.8
19	00K-0147	Frank	Francis	29169-6945381-3	michelle64@gmail.com	+92 6118269913	107	2.33	99982	99K-9773	John	Baker	89782-7898556-9	jamesbarnes@gmail.com	+92 1481674673	104	2.25
20	00K-0150	Connor	Watts	83591-3827040-4	carolyn56@gmail.com	+92 7829957175	100	2.53	99983	99K-9774	Michael	Alexander	12668-3042965-2	armyflower@gmail.com	+92 0285071489	113	3.32
21	00K-0159	Paige	Robinson	98058-3897689-9	april16@gmail.com	+92 2637699708	73	3.24	99984	99K-9776	Cody	Lopez	64602-2036425-2	charles16@gmail.com	+92 3189562692	50	3.48
22	00K-0161	Melanie	Smith	20134-4696525-8	geraldjones@gmail.com	+92 7596748739	92	2.76	99985	99K-9780	Stephen	Malone	96810-3416733-4	gallen@gmail.com	+92 9259598714	55	3.28
23	00K-0176	Richard	Graves	94655-5815755-3	hughesmarilyn@gmail.com	+92 7669222242	83	3.73	99986	99K-9808	Gina	Lynch	26207-8728177-2	jacobstevens@gmail.com	+92 3099452670	66	3.65
24	00K-0177	Daniel	Garcia	16344-2129803-4	marysawyer@gmail.com	+92 886381164	37	2.39	99987	99K-9810	Courtney	Santiago	65390-6388702-2	pcarroll@gmail.com	+92 7199193501	50	2.86
25	00K-0215	Manuel	Green	72962-6437054-5	jimmy45@gmail.com	+92 1384405038	25	3.83	99988	99K-9816	Brittany	Huang	29232-7963918-4	christina35@gmail.com	+92 5970606250	77	3.87
26	00K-0221	Kimberly	Lewis	73072-1083774-3	christopher76@gmail.com	+92 6921031254	87	2.45	99989	99K-9827	Kerry	Campbell	69554-0524351-7	nicholasquinn@gmail.com	+92 1645505353	101	3.2
27	00K-0232	Allison	Cole	84071-3130022-3	masondonald@gmail.com	+92 8781486008	61	3.34	99990	99K-9839	Julie	Joseph	12505-1085030-7	wadams@gmail.com	+92 7646313615	35	2
28	00K-0233	Carla	Russell	61911-6860983-3	jessica92@gmail.com	+92 7364737153	119	3.82	99991	99K-9867	Corey	Welch	16337-2393050-2	amanda97@gmail.com	+92 9892988779	48	2.55
29	00K-0235	Elizabeth	Gonzalez	90342-8874515-6	randersen@gmail.com	+92 6745906447	20	2.46	99992	99K-9869	Kelli	Jackson	55240-7060361-9	melindamason@gmail.com	+92 8744666750	92	2.59
30	00K-0243	William	Flores	32268-2485729-9	guyhouston@gmail.com	+92 9212955147	63	3.6	99993	99K-9893	Wendy	Lewis	24420-2787036-4	thomasshaw@gmail.com	+92 7896946774	130	3.91
31	00K-0255	Mikayla	Moss	73024-6856279-5	katrinasanchez@gmail.com	+92 4932793636	77	3.84	99994	99K-9895	Christina	Hood	61510-2304262-4	griffithbenjamin@gmail.com	+92 4480369048	66	3.12
32	00K-0261	Heidi	Martinez	31021-1760599-9	jenniferbray@gmail.com	+92 5140675944	44	2.41	99995	99K-9914	David	Kramer	81275-4873758-3	tylerbown@gmail.com	+92 1254141033	72	2.74
33	00K-0289	Kenneth	Odom	19785-9379406-8	gregorysantos@gmail.com	+92 1124755323	40	3.85	99996	99K-9919	Christine	Ballard	45042-5611618-2	ana58@gmail.com	+92 1200026094	59	3.56
34	00K-0291	Dwayne	Larsen	43707-2866819-3	brian72@gmail.com	+92 6287932428	35	2.83	99997	99K-9922	Eric	Bailey	48450-4025687-3	owoodward@gmail.com	+92 4697183790	45	3.2
35	00K-0304	Sarah	Romero	85235-7227591-9	taylormartin@gmail.com	+92 8218198603	112	3.52	99998	99K-9933	Angela	Wong	35632-6767246-3	qvasquez@gmail.com	+92 3014876414	107	3.55
36	00K-0306	Holly	Trujillo	29202-3197771-6	taylorlara@gmail.com	+92 3233676311	119	2.3	99999	99K-9974	Deanna	Jones	50041-0470477-4	stanleydeborah@gmail.com	+92 0673782651	102	3.15
37	00K-0313	Debra	Snyder	62140-1679477-1	mary22@gmail.com	+92 3885278676	43	3.38	100000	99K-9988	Kevin	Allen	53006-4313585-0	pricvalerie@gmail.com	+92 0389600267	60	3.25
38	00K-0314	Michelle	Carlson	35348-0808223-5	qlclark@gmail.com	+92 3466038723	90	3.15	100001	99K-9997	Kyle	Rice	53801-0030417-5	hartmanleslie@gmail.com	+92 2996749988	90	2.88

Dataset after sorting in parallel(start and end of sorted file shown, please zoom in to see clearly):

1	Student ID	First Name	Last Name	CNIC	Email	Phone Number	Credit Hours	CGPA	99964	99K-9676	Cindy	Reed	74494-7279710-7	qsnyder@gmail.com	+92 5865685608	37	3.43
2	00K-0003	Joshua	Curtis	86913-2638977-2	loriballard@gmail.com	+92 3267714395	92	3.23	99965	99K-9682	Danielle	Bryant	74233-0673746-0	matthewadams@gmail.com	+92 7810597692	70	3.72
3	00K-0018	Joanna	Preston	16696-5325280-7	charles76@gmail.com	+92 6913000575	56	3.77	99966	99K-9683	Christopher	Wilson	78184-6268847-6	wkelley@gmail.com	+92 4141731119	69	2.37
4	00K-0025	Christian	Barker	53821-0252968-7	kaitlynkim@gmail.com	+92 2501995935	118	3.61	99967	99K-9687	Ronald	Cameron	70311-5625512-7	esilva@gmail.com	+92 9718373697	87	3.2
5	00K-0026	Jennifer	Roberts	83938-9522082-2	qlang@gmail.com	+92 8318694854	109	3.84	99968	99K-9691	John	Smith	90456-2664873-7	haley37@gmail.com	+92 8094893429	68	3.71
6	00K-0029	Katherine	Gomez	99721-9702287-0	powersheather@gmail.com	+92 2558579456	70	2.51	99969	99K-9695	Heather	Reilly	90564-6909426-3	gcooper@gmail.com	+92 5774207020	47	3.57
7	00K-0043	Sarah	Parsons	79038-9691638-9	rayryan@gmail.com	+92 6053638040	39	3.1	99970	99K-9697	Carla	Carter	45759-9212543-6	terrygarcia@gmail.com	+92 7726364671	124	3.71
8	00K-0051	Edward	Thomas	17571-4164701-0	morrowkevin@gmail.com	+92 7011578446	65	3.11	99971	99K-9701	Christina	Curtis	94503-8601745-3	paulporter@gmail.com	+92 7438690253	72	3.2
9	00K-0053	Alexis	Waters	99122-5384944-3	james55@gmail.com	+92 7888298849	103	3.19	99972	99K-9724	Mary	Suarez	24053-6165306-6	steven16@gmail.com	+92 3578810326	129	2
10	00K-0068	Nicholas	Frost	70498-7015299-7	andradeaustin@gmail.com	+92 9042444576	44	2.83	99973	99K-9725	Gary	Wong	24221-0189126-2	benjamin62@gmail.com	+92 9020724251	34	3.69
11	00K-0076	Timothy	Norris	96025-8464314-1	daniel81@gmail.com	+92 2883077758	104	3.95	99974	99K-9731	Cody	Adams	52169-2916245-0	kelleywilliam@gmail.com	+92 1810067571	108	2.62
12	00K-0082	Kathryn	Evans	10117-6854597-0	mbowman@gmail.com	+92 0045469336	111	3.1	99975	99K-9741	Lisa	Martinez	43804-2716422-6	christine32@gmail.com	+92 822255468	58	2.69
13	00K-0084	Robert	Bauer	69210-3004788-3	robert62@gmail.com	+92 0065934087	72	3.67	99976	99K-9743	Jeffery	Pham	19766-1852117-7	xryan@gmail.com	+92 4087230892	35	3.3
14	00K-0088	Cheryl	Ortiz	21023-2992469-6	brian20@gmail.com	+92 4728906086	53	3.96	99977	99K-9753	Jamie	Moreno	90733-1370396-8	vanessalynch@gmail.com	+92 5039227250	57	2.3
15	00K-0090	Donald	Delacruz	67967-2597381-5	hlopez@gmail.com	+92 6644873987	57	2.98	99978	99K-9763	Jennifer	Odom	26668-9482039-4	steverwilliams@gmail.com	+92 6058959793	45	3.49
16	00K-0124	Nicole	Shannon	86090-1932288-1	tfritz@gmail.com	+92 2138375934	72	3.34	99979	99K-9765	Gregory	Jacobson	88329-0558109-5	kevin64@gmail.com	+92 3763510274	66	3.27
17	00K-0129	Jennifer	Wilcox	81511-9575060-9	littledavid@gmail.com	+92 0922292379	47	2.22	99980	99K-9767	Adriana	Salazar	41486-0198108-1	jamesclark@gmail.com	+92 9116620205	68	3.93
18	00K-0131	Angela	Henry	89505-375552-4	sharonrivera@gmail.com	+92 3465302006	93	3.53	99981	99K-9769	James	Watson	24491-0790700-6	richardlutz@gmail.com	+92 3420556084	59	2.8
19	00K-0147	Frank	Francis	29169-6945381-3	michelle64@gmail.com	+92 6118269913	107	2.33	99982	99K-9773	John	Baker	89782-7898556-9	jamesbarnes@gmail.com	+92 1481674673	104	2.25
20	00K-0150	Connor	Watts	83591-3827040-4	carolyn56@gmail.com	+92 7829957175	100	2.53	99983	99K-9774	Michael	Alexander	12668-3042965-2	armyflower@gmail.com	+92 0285071489	113	3.32
21	00K-0159	Paige	Robinson	98058-3897689-9	april16@gmail.com	+92 2637699708	73	3.24	99984	99K-9776	Cody	Lopez	64602-2036425-2	charles16@gmail.com	+92 3189562692	50	3.48
22	00K-0161	Melanie	Smith	20134-4696525-8	geraldjones@gmail.com	+92 7596748739	92	2.76	99985	99K-9780	Stephen	Malone	96810-3416733-4	gallen@gmail.com	+92 9259598714	55	3.28
23	00K-0176	Richard	Graves	94655-5815755-3	hughesmarilyn@gmail.com	+92 7669222242	83	3.73	99986	99K-9808	Gina	Lynch	26207-8728177-2	jacobstevens@gmail.com	+92 3099452670	66	3.68
24	00K-0177	Daniel	Garcia	16344-2129803-4	marysawyer@gmail.com	+92 4886381136	37	2.39	99987	99K-9810	Courtney	Santiago	65390-638702-0	pcarroll@gmail.com	+92 7199193501	50	2.86
25	00K-0215	Manuel	Green	72962-6437054-5	jimmy45@gmail.com	+92 1384405604	25	3.83	99988	99K-9816	Brittany	Huang	29232-7969818-4	christina35@gmail.com	+92 5970606250	77	3.81
26	00K-0221	Kimberly	Lewis	73072-1083774-5	christopher76@gmail.com	+92 6921031254	87	2.45	99989	99K-9827	Kerry	Campbell	69554-0524351-7	nicholasquinn@gmail.com	+92 1645505353	101	3.2
27	00K-0232	Allison	Cole	84071-3130022-3	masondonald@gmail.com	+92 8781486008	61	3.34	99990	99K-9839	Julie	Joseph	12505-1085030-0	wadams@gmail.com	+92 7646313615	35	3.5
28	00K-0233	Carla	Russell	69191-6809983-3	jessica92@gmail.com	+92 7354737153	119	3.82	99991	99K-9867	Corey	Welch	13337-2393050-9	amanda97@gmail.com	+92 9982998779	48	2.55
29	00K-0235	Elizabeth	Gonzalez	90342-8874515-6	nandersen@gmail.com	+92 6745906447	20	2.46	99992	99K-9869	Kelli	Jackson	55240-7060361-9	melindamason@gmail.com	+92 8744668579	92	2.58
30	00K-0243	William	Flores	73228-2485729-9	guyhouston@gmail.com	+92 9122955147	63	3.6	99993	99K-9895	Wendy	Levis	24420-2708736-4	tomashawsh@gmail.com	+92 7808948674	130	3.91
31	00K-0255	Mikayla	Moss	32064-6852796-3	katrinasanchez@gmail.com	+92 4932793636	77	3.84	99994	99K-9895	Christina	Hood	61510-2304262-4	griffithbenjamin@gmail.com	+92 4801380948	66	3.12
32	00K-0261	Heidi	Martinez	31021-1760599-9	jenniferbray@gmail.com	+92 5140675944	44	2.41	99995	99K-9914	David	Kramer	81275-4873758-3	griffitbown@gmail.com	+92 1254141033	72	2.74
33	00K-0269	Kenneth	Odum	19785-9379406-8	gregorysantos@gmail.com	+92 1124755524	40	3.85	99996	99K-9919	Christine	Ballard	45042-5611618-2	ane58@gmail.com	+92 1200206084	79	3.56
34	00K-0291	Dwayne	Larsen	43707-2866819-3	brian72@gmail.com	+92 6287923608	35	2.83	99997	99K-9922	Eric	Ballard	48450-4025687-3	owoodward@gmail.com	+92 4607183790	45	3.4
35	00K-0304	Sarah	Romero	85235-7227591-9	taylormartin@gmail.com	+92 8218198603	112	3.52	99998	99K-9933	Angela	Wong	35632-6727643-3	vasquezv@gmail.com	+92 3014876414	107	3.55
36	00K-0310	Heidy	Trujillo	92323-33771-6	taylorlara@gmail.com	+92 3233676311	119	2.31	99999	99K-9974	Deanna	Jones	50001-0470477-4	stanleydeborah@gmail.com	+92 0673782651	102	3.51
37	00K-0313	Debra	Snyder	62140-1679477-1	mary22@gmail.com	+92 3885278616	43	3.38	100000	99K-9988	Kevin	Allen	53006-4313585-0	pricevalerie@gmail.com	+92 0389600267	60	3.25
38	00K-0314	Michelle	Carlson	35348-0802235	qclark@gmail.com	+92 3466038723	90	3.15	100001	99K-9997	Kyle	Rice	53801-0030417-5	hartmanleslie@gmail.com	+92 2996749988	90	2.88

Thread log created after sorting in parallel:

```
parallel > threadlog.txt
99984 Thread 2 took 0.000001s to merge the chunk from index 0 to 6 of size 7
99985 Thread 2 took 0.000001s to merge the chunk from index 0 to 12 of size 13
99986 Thread 2 took 0.000001s to merge the chunk from index 0 to 24 of size 25
99987 Thread 2 took 0.000003s to merge the chunk from index 0 to 48 of size 49
99988 Thread 2 took 0.000005s to merge the chunk from index 0 to 97 of size 98
99989 Thread 2 took 0.000010s to merge the chunk from index 0 to 195 of size 196
99990 Thread 2 took 0.000020s to merge the chunk from index 0 to 390 of size 391
99991 Thread 1 took 0.000330s to merge the chunk from index 6250 to 12499 of size 6250
99992 Thread 2 took 0.000039s to merge the chunk from index 0 to 781 of size 782
99993 Thread 2 took 0.000078s to merge the chunk from index 0 to 1562 of size 1563
99994 Thread 2 took 0.000156s to merge the chunk from index 0 to 3124 of size 3125
99995 Thread 2 took 0.000311s to merge the chunk from index 0 to 6249 of size 6250
99996 Thread 1 took 0.000681s to merge the chunk from index 0 to 12499 of size 12500
99997 Thread 1 took 0.001385s to merge the chunk from index 0 to 24999 of size 25000
99998 Thread 3 took 0.002838s to merge the chunk from index 0 to 49999 of size 50000
99999 Thread 0 took 0.005893s to merge the chunk from index 0 to 99999 of size 100000
100000
```

## Conclusion

The results above (specifically the graph) lead us to conclude that as the size of the dataset (Number of Records in the dataset) increases, the benefits of parallel programming become more visible and apparent since the runtime of the parallel application rises slowly compared to that of the serial application. Especially in this era of “Big Data”, where the size of data available and required to be processed is rapidly increasing, it would be highly beneficial to parallelize sorting, since it's such an essential subprocess in many processes, so more time can be spent on actually using this data than it is spent processing it.