CS 475/575 -- Spring Quarter 2025

Project #3

K-means: A Real Application Parallel Challenge

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1. Data Table

	NUMT	NUMCITIES	NUMCAPITALS	megaCityCapitalsPerSecond
1	NUMT	NUMCITIES	NUMCAPITALS	megaCityCapitalsPerSecond
2	1	331	2	44.787
3	1	331	3	53.851
4	1	331	4	56.855
5	1	331	5	41.449
6	1	331	10	5.321
7	1	331	15	39.573
8	1	331	20	41.059
9	1	331	30	90.734
10	1	331	40	82.721
11	1	331	50	100.103
12	2	331	2	11.873
13	2	331	3	16.424
14	2	331	4	22.94
15	2	331	5	27.576
16	2	331	10	68.192
17	2	331	15	88.882
18	2	331	20	48.303
19	2	331	30	124.598
20	2	331	40	99.726
21	2	331	50	133.392
22	4	331	2	7.379
23	4	331	3	11.51
24	4	331	4	14.617
25	4	331	5	18.884
26	4	331	10	37.211
27	4	331	15	28.065
28	4	331	20	75.515
29	4	331	30	119.984
30	4	331	40	135.775
31	4	331	50	184.034
32	6	331	2	6.645
33	6	331	3	7.512
34	6	331	4	11.733
35	6	331	5	4.954

36	6	331	10		31.033
37	6	331	15		49.968
38	6	331	20		62.689
39	6	331	30		101.478
40	6	331	40		135.007
41	6	331	50		124.171
42	8	331	2		0.227
43	8	331	3		8.085
44	8	331	4		10.591
45	8	331	5		12.988
46	8	331	10		27.177
47	8	331	15		11.136
48	8	331	20		11.905
49	8	331	30		88.93
50	8	331	40		111.278
51	8	331	50		137.25

Row Labels	1	2	4	6	8
2	44.787	11.873	7.379	6.645	0.227
3	53.851	16.424	11.51	7.512	8.085
4	56.855	22.94	14.617	11.733	10.591
5	41.449	27.576	18.884	4.954	12.988
10	5.321	68.192	37.211	31.033	27.177
15	39.573	88.882	28.065	49.968	11.136
20	41.059	48.303	75.515	62.689	11.905
30	90.734	124.598	119.984	101.478	88.93
40	82.721	99.726	135.775	135.007	111.278
50	100.103	133.392	184.034	124.171	137.25

2. Graph of performance vs. number of threads with the colored curves being NUMCAPITALS

Graph of performance vs. number of threads
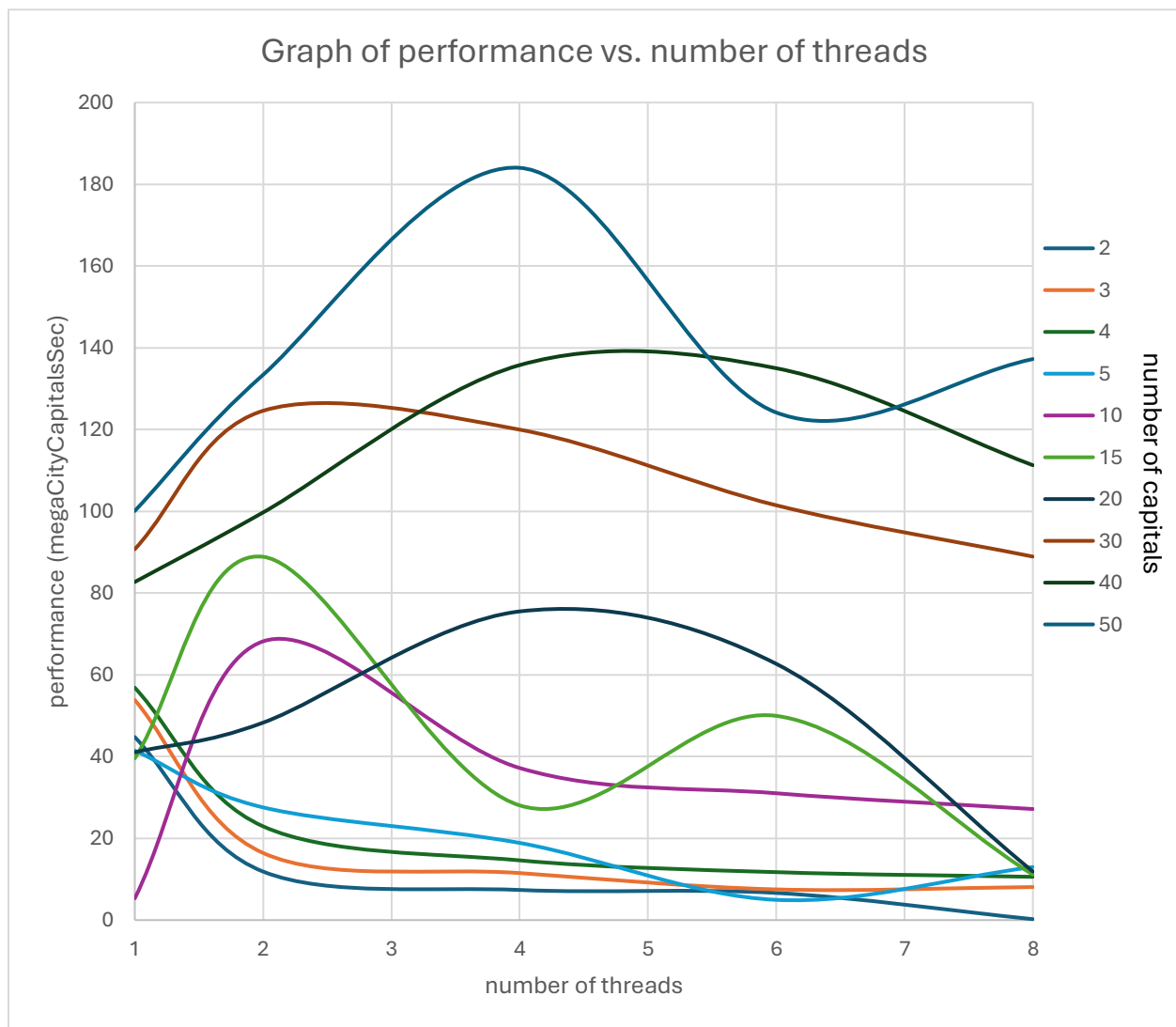
3. Graph of performance vs. number of capital cities with the colored curves being NUMT

Graph of performance vs. number of capital cities
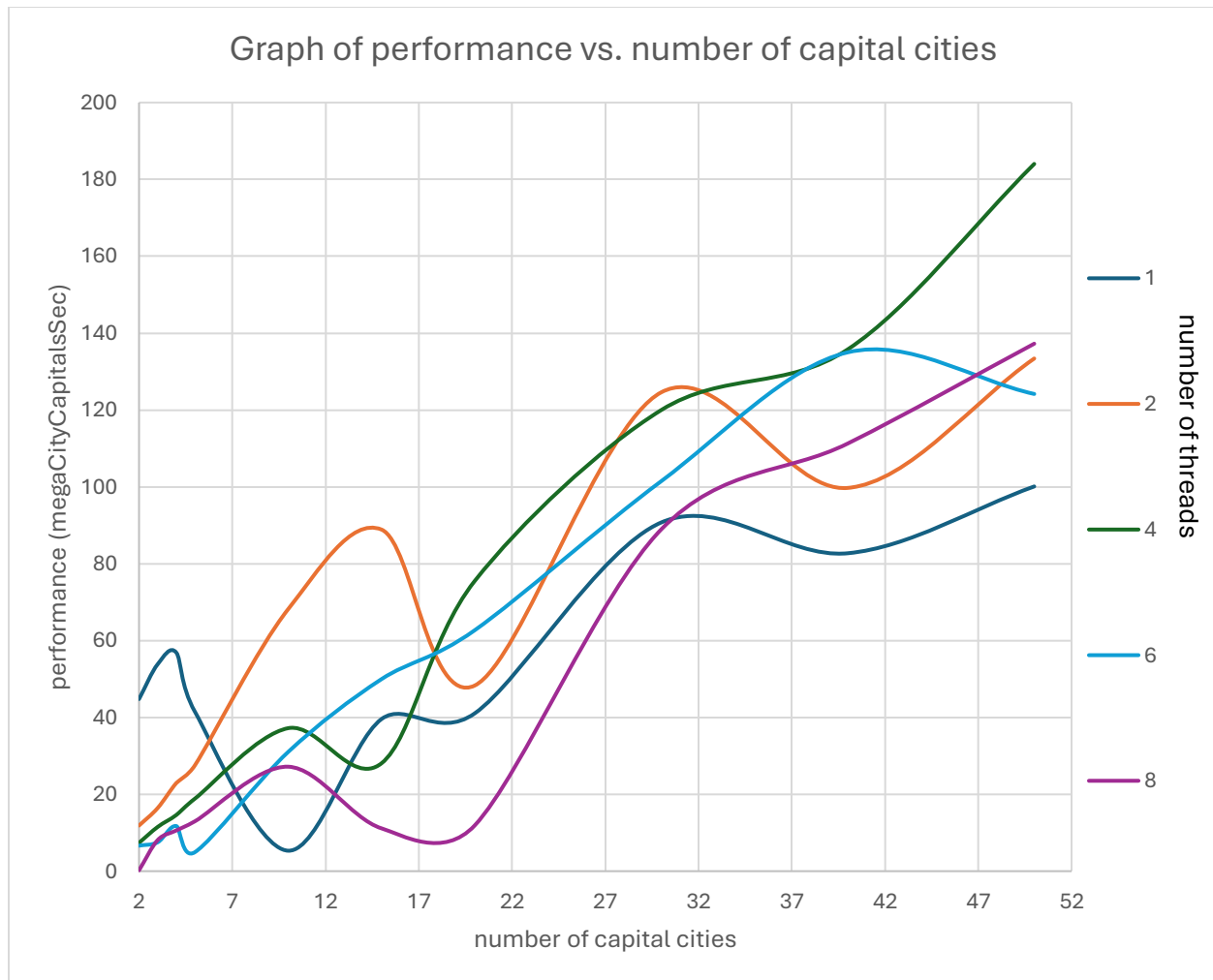
4. Commentary

1. Tell what machine you ran this on: -
   Flip
   Linux flip2.engr.oregonstate.edu 5.14.0-503.33.1.el9_5.x86_64 #1 SMP PREEMPT_DYNAMIC Wed Mar 19 16:23:31 UTC 2025 x86_64 x86_64 x86_64 GNU/Linux

2. Tell what operating system you were using: -
   Linux

3. Tell what compiler you used: -

   g++ (GCC) 11.5.0 20240719 (Red Hat 11.5.0-5)

4. Tell us what you discovered by doing this. What patterns are you seeing in the graphs?

As I experimented with different numbers of threads and capital cities, I found that parallel computing does help speed things upbut only to a point. Using more threads generally improved the performance at first, but after 4 threads, I noticed the improvements weren't as strong. Surprisingly, 4 threads gave the fastest results in many cases.

This made me realize that sometimes having too many threads can backfire. When there are more threads than the system can handle smoothly, they might end up waiting on each other or using shared resources inefficiently. It was interesting to see that the best performance came not from the maximum number of threads, but from a setup where the workload was well balanced and didn't overload the system.

5. Extra Credit: print the list of the final capital cities

2 capitals

	longitude	latitude	city	state
0	85.82	36.04	Murfreesbor	TN
1	116.27	37.16	LasVegas	NV

3 capitals

	longitude	latitude	city	state
0	77.42	39.58	Washington	DC
1	90.98	33.99	Memphis	TN
2	116.71	37.28	LasVegas	NV

4 capitals

	longitude	latitude	city	state
0	74.24	40.72	Newark	NJ
1	83.91	35.14	Knoxville	TN
2	98.01	35	OklahomaCi	OK
3	118.27	37.15	Visalia	CA

5 capitals

	longitude	latitude	city	state
0	74.24	40.72	Newark	NJ
1	108.1	36.56	RioRancho	NM
2	82.85	34.2	Athens	GA
3	94.64	35.37	BrokenArrow	OK
4	119.45	37.39	Clovis	CA

10 capitals

	longitude	latitude	city	state
0	74.1	40.73	JerseyCity	NJ
1	92.01	41.15	CedarRapids	IA
2	111.39	33.45	Mesa	AZ
3	81.58	28.82	Orlando	FL
4	120.86	45.93	Gresham	OR
5	117.77	34.11	Pomona	CA
6	96.7	31.77	Waco	TX
7	106.77	39.74	Boulder	CO
8	83.57	37.95	Lexington	KY
9	121.65	37.98	Antioch	CA

15 capitals

	longitude	latitude	city	state
0	73.03	41.52	Waterbury	CT
1	112.53	35.42	Peoria	AZ
2	119.66	36.04	Visalia	CA
3	96.97	31.62	Waco	TX
4	120.86	45.93	Gresham	OR
5	80.99	27.33	PortSt.Lucie	FL
6	86.47	33.49	Birmingham	AL
7	78.58	36	Raleigh	NC
8	82.22	41.8	Cleveland	OH
9	87.51	40.93	Joliet	IL
10	94.56	40.89	DesMoines	IA
11	105.34	38.45	ColoradoSpr	CO
12	118.41	34.17	Burbank	CA
13	117.47	33.72	Corona	CA
14	121.8	38.07	Antioch	CA

20 capitals

	longitude	latitude	city	state
0	71.89	42.1	Worcester	MA
1	121.03	47.58	Bellevue	WA
2	120.46	39.63	Reno	NV
3	96.22	29.13	SugarLand	TX
4	88.08	41.5	Joliet	IL
5	78.79	35.47	Cary	NC
6	119.66	36.04	Visalia	CA
7	97.41	33.42	Denton	TX
8	85.75	32.61	Montgomery	AL
9	117.65	34.02	Ontario	CA
10	80.98	27.1	PortSt.Lucie	FL
11	106.77	39.74	Boulder	CO
12	75.05	40.63	Allentown	PA
13	82.76	41.65	Dearborn	MI
14	121.75	38.23	Antioch	CA
15	111.39	33.45	Mesa	AZ
16	86.22	36.62	Nashville	TN
17	120.73	44.6	Bend	OR
18	94.4	41.06	DesMoines	IA
19	122.18	37.54	Hayward	CA

30 capitals

	longitude	latitude	city	state
0	74.5	40.78	Woodbridge	NJ
1	121.67	37.41	SanJose	CA
2	78.82	42.17	Buffalo	NY
3	120.93	39.1	Roseville	CA
4	94.48	44.87	Minneapolis	MN
5	119.6	36.65	Clovis	CA
6	105.18	39.06	ColoradoSpr	CO
7	89.23	42.98	Madison	WI
8	113.17	42.36	SaltLakeCity	UT
9	80.98	27.1	PortSt.Lucie	FL
10	73.1	41.67	Waterbury	CT
11	86.03	32.56	Montgomery	AL
12	76.62	37.67	NewportNev	VA
13	122.87	38.09	SantaRosa	CA
14	111.39	33.45	Mesa	AZ
15	94.79	38.59	Olathe	KS
16	88.97	41.07	Peoria	IL
17	118.02	34	ElMonte	CA
18	116.93	34.01	MorenoValle	CA
19	97.95	32.87	FortWorth	TX
20	119.26	34.53	Ventura	CA
21	79.93	34.72	Concord	NC
22	86.39	36.37	Nashville	TN
23	71.21	42.29	Cambridge	MA
24	121.03	47.58	Bellevue	WA
25	94.57	30.38	Beaumont	TX
26	122.58	45.04	Salem	OR
27	98.17	27.57	CorpusChris	TX
28	84.14	41.3	Toledo	OH
29	122.17	37.92	Berkeley	CA

40 capitals

	longitude	latitude	city	state
0	78.15	42.39	Buffalo	NY
1	95.65	36.07	BrokenArrow	OK
2	122.46	37.89	Richmond	CA
3	122.26	47.55	Renton	WA
4	119.6	36.65	Clovis	CA
5	117.67	33.81	Anaheim	CA
6	96.88	32.97	Carrollton	TX
7	97.76	26.57	Edinburg	TX
8	79.48	35.57	Greensboro	NC
9	84.23	40.98	FortWayne	IN
10	99.49	27.56	Laredo	TX
11	82.36	27.69	St.Petersbur	FL
12	113.32	38.49	St.George	UT
13	76.62	37.67	NewportNev	VA
14	94.47	41.29	DesMoines	IA
15	87.6	34.06	Tuscaloosa	AL
16	110.66	33.44	Mesa	AZ
17	122.21	44.06	Bend	OR
18	80.29	25.92	Hialeah	FL
19	97.61	30.46	RoundRock	TX
20	80.32	33.26	NorthCharle	SC
21	88.76	41.47	Aurora	IL
22	82.75	30.16	Gainesville	FL
23	84.31	33.96	SandySpring	GA
24	74.35	40.58	Woodbridge	NJ
25	80.26	27.01	WestPalmBe	FL
26	101.58	33.02	Lubbock	TX
27	93.92	30.15	Beaumont	TX
28	80.96	28.18	Orlando	FL
29	81.61	32.68	Savannah	GA
30	73.1	41.67	Waterbury	CT

31	105.21	40.18	Boulder	CO
32	122.73	45.43	Portland	OR
33	119.03	34.54	Ventura	CA
34	120.46	39.63	Reno	NV
35	80.2	26.15	FortLauderd	FL
36	71.13	41.85	Brockton	MA
37	116.77	45.22	Meridian	ID
38	71.24	42.48	Cambridge	MA
39	121.72	37.85	Antioch	CA

50 capitals

	longitude	latitude	city	state
0	74.08	40.68	JerseyCity	NJ
1	98.1	26.77	Edinburg	TX
2	83.9	39.64	Dayton	OH
3	85.24	33.6	SouthFulton	GA
4	85.45	36.84	Louisville	KY
5	119.6	36.65	Clovis	CA
6	77.31	36.38	NewportNev	VA
7	119.04	35.35	Bakersfield	CA
8	83.74	42.42	AnnArbor	MI
9	82.42	28.83	Gainesville	FL
10	80.43	34.46	Columbia	SC
11	114.74	36.4	NorthLasVeg	NV
12	85.94	40.5	Fishers	IN
13	112	33.37	Tempe	AZ
14	122.26	47.55	Renton	WA
15	117.33	34.47	Victorville	CA
16	117.44	34.03	JurupaValley	CA
17	108.55	45.79	Billings	MT
18	101.58	33.02	Lubbock	TX
19	88.97	41.99	Rockford	IL
20	81.06	41	Akron	OH
21	91.08	31.55	BatonRouge	LA
22	88.77	37.08	Clarksville	TN
23	104.93	39.71	Denver	CO
24	122.17	37.92	Berkeley	CA
25	71.21	42.29	Cambridge	MA
26	117.13	32.95	SanDiego	CA
27	95.18	29.78	Pasadena	TX
28	77.54	43.03	Rochester	NY
29	76.9	39.01	Washington	DC
30	94.34	44.32	Minneapolis	MN
31	75.31	40.3	Philadelphia	PA

	70.02	70.0	Philadelphia PA
32	116.4	43.6	Meridian	ID
33	121.67	37.41	SanJose	CA
34	97.61	30.46	RoundRock	TX
35	95.04	38.65	Olathe	KS
36	120.93	39.1	Roseville	CA
37	111.98	40.69	WestValleyC	UT
38	73.03	41.77	Waterbury	CT
39	111.65	40.25	Provo	UT
40	117.17	33.58	Murrieta	CA
41	117.33	47.67	Spokane	WA
42	119.63	34.47	Ventura	CA
43	106.64	33.64	LasCruces	NM
44	80.4	26.36	CoralSprings	FL
45	117.93	33.85	Fullerton	CA
46	118.38	34.23	Burbank	CA
47	96.94	33.22	Frisco	TX
48	122.58	45.04	Salem	OR
49	122.87	38.09	SantaRosa	CA