

**Student Report for  
National Science Foundation (NSF)  
China-IRES Research Trip to  
Tsinghua University, Beijing  
Summer 2019**



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National Science Foundation  
WHERE DISCOVERIES BEGIN

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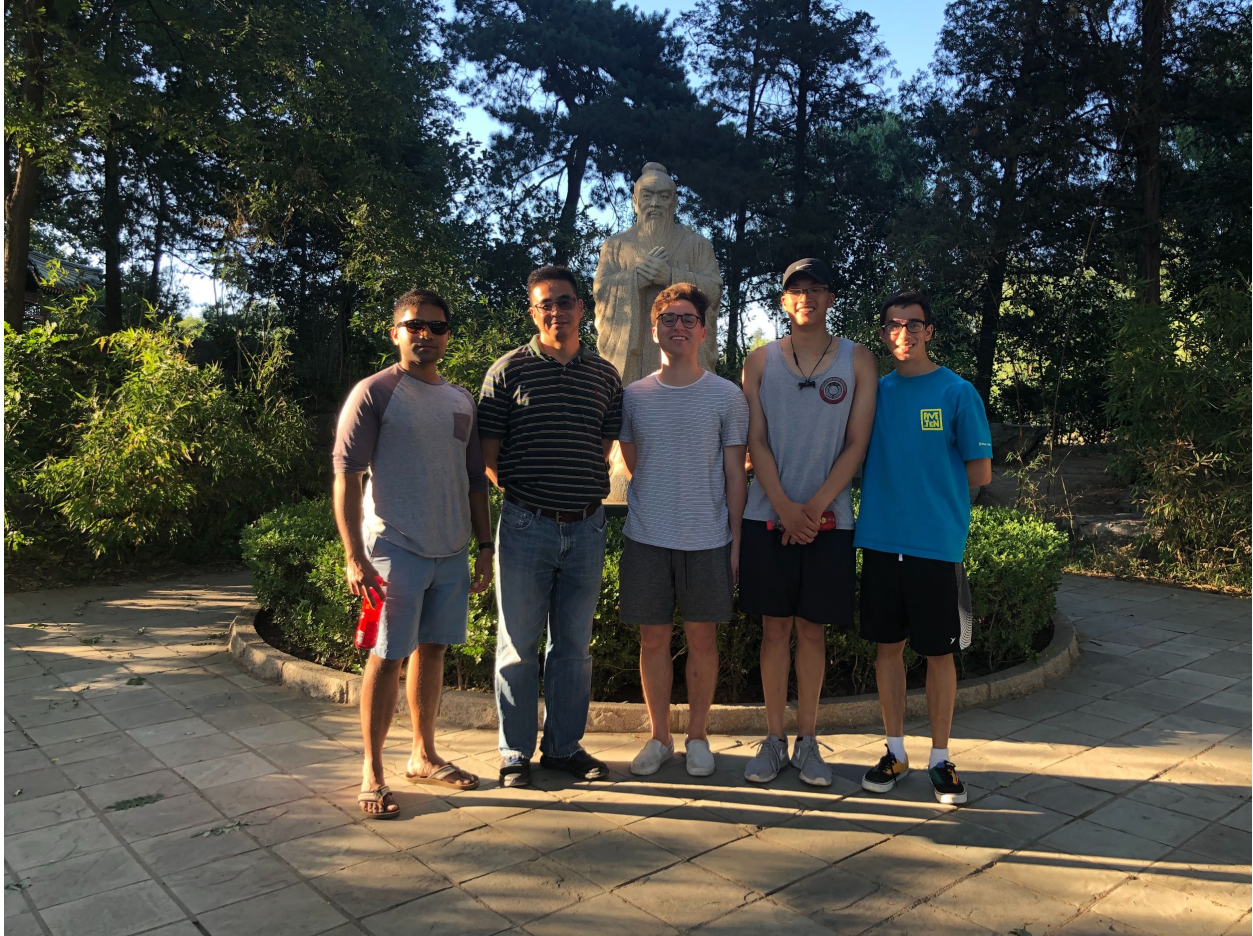
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## 1. INTRODUCTION

The IRES program provides undergraduate students the opportunity to gain invaluable research experience by working closely with a graduate student and make meaningful contributions. In this program, the students are exposed to unique international experiences for career development and cultural exploration.

This year, three students got the amazing opportunity to participate in the IRES program. We were excited and lucky to have been selected to participate in the IRES program. The IRES program lasted 9 weeks, June 28 to September 1, 2019, where we did research at the prestigious Tsinghua University. We were very happy to be able to participate in research at Tsinghua University since it was one of the top universities in China. During the length of the program, we worked with Sheriff Sadiqbatcha, a Ph.D. student from the University of California Riverside, who came with us. We worked on the Post-Silicon Thermal Modeling and Dynamic Control Project with Sheriff Sadiqbatcha during our stay.

## 1.1 Undergraduate Research Team



**From Left to Right:** Sheriff Sadiqbatcha - EE Phd. Candidate, Professor Sheldon X. -D. Tan. - Department of Electrical Engineering at UC Riverside, Carson Welty - CS Junior, Winson Bi - CE Senior, Cole Pivonka - CE Junior

## 1.2 Pre-departure

During the Spring Quarter of 2019, we met with Dr. Tan on a bi-weekly basis to talk about the trip. We discussed the objectives and goals of the Post-Silicon Thermal Modeling and Dynamic Control Project that Sheriff had been working on. We also worked over the Spring Quarter in Professor Tan's lab to gain more research experience to prepare us for the trip. We also met up with Guadalupe Ruiz who was in charge of students abroad. Ms. Ruiz helped us fill out the necessary paperwork and medical forms for us to go abroad.

## 2. RESEARCH

### 2.1 Background

For the Post-Silicon Thermal Modeling and Dynamic Control Project that Sheriff had been working on. The research presented a novel approach for detecting the temperature of an integrated chip. Instead of using thermal sensors, which were sparse on the chip, this approach used a thermal camera along with CPU and GPU metrics to develop a model that gave a thermal map of the entire chip. Next, was to improve the chip's performance with this new thermal data.

### 2.2 Objective

- Obtain meaningful CPU metrics that correlated with the stress of the chip and its current performance
- Obtain meaningful GPU metrics that correlated with the stress of the chip and its current performance
- Use the CPU and GPU metrics to create a model that would give us an accurate representation of the chip's thermal map
- Develop a method that allows us to control the CPU's performance
- Understand the chips current power and thermal control schemes

### 2.3 Result

After finding suitable programs that gave us meaningful CPU metrics and GPU metrics. We collected CPU and GPU metrics under different levels of stress. First we would collect CPU and GPU metrics in CSV files when the chip was idle to have a benchmark. We then ran stress tests that included putting both just a single core under load and all eight cores under load while we collected the CPU and GPU metrics under those loads.

```
(base) [vsclab_thinkpad@localhost gputop-master]$ sudo ./build/wrapper/gputop-wrapper -m L3_3 -c AvgGpuCoreFrequency,CsThreads,DsThreads,GpuBusy -P 0.016
Server: localhost:7890
Sampling period: 16 ms
Monitoring: system wide
Connected

System info:
  Kernel release: 5.0.9-301.fc30.x86_64
  Kernel build: #1 SMP Tue Apr 23 23:57:35 UTC 2019
CPU info:
  CPU model: Intel(R) Core(TM) i7-8650U CPU @ 1.90GHz
  CPU cores: 8
GPU info:
  GT name: KabyLake GT2 (Gen 9, PCI 0x5917)
  Topology: 168 threads, 24 EUs, 1 slices, 3 subslices
  GT frequency range: 300.0MHz / 1150.0MHz
  CS timestamp frequency: 12000000 Hz / 83.33 ns
OA info:
  OA Hardware Sampling Exponent: 16
  OA Hardware Period: 10922666 ns / 10.92 ms
Current time: 08/08/19 03:37:05.950629893 UTC
CPUTime, AvgGpuCoreFrequency, CsThreads, DsThreads, GpuBusy
(ns), (Hz), (threads), (threads), (%)
08/08/19 03:37:06.037763578, 1.107 GHz, 0 threads, 0 threads, 59.4 %
08/08/19 03:37:06.037950268, 1.095 GHz, 0 threads, 0 threads, 30.7 %
08/08/19 03:37:06.057094405, 1.081 GHz, 0 threads, 0 threads, 61 %
08/08/19 03:37:06.072021820, 1.063 GHz, 0 threads, 0 threads, 4.73 %
08/08/19 03:37:06.086880062, 1.022 GHz, 0 threads, 0 threads, 0 %
08/08/19 03:37:06.107029710, 989.4 MHz, 0 threads, 0 threads, 69.5 %
08/08/19 03:37:06.122287979, 976.9 MHz, 0 threads, 0 threads, 33.6 %
08/08/19 03:37:06.1418181635, 974.2 MHz, 0 threads, 0 threads, 73.7 %
08/08/19 03:37:06.157443560, 966.5 MHz, 0 threads, 0 threads, 25.9 %
08/08/19 03:37:06.176956878, 986.6 MHz, 0 threads, 0 threads, 78.3 %
08/08/19 03:37:06.192579510, 997.7 MHz, 0 threads, 0 threads, 14.2 %
08/08/19 03:37:06.206933458, 995.4 MHz, 0 threads, 0 threads, 84 %
08/08/19 03:37:06.227294003, 993.1 MHz, 0 threads, 0 threads, 6.24 %
08/08/19 03:37:06.241931504, 991.2 MHz, 0 threads, 0 threads, 88.4 %
08/08/19 03:37:06.257470700, 985.9 MHz, 0 threads, 0 threads, 0 %
08/08/19 03:37:06.276969616, 994.5 MHz, 0 threads, 0 threads, 89.2 %
08/08/19 03:37:06.292321410, 987.7 MHz, 0 threads, 0 threads, 0 %
08/08/19 03:37:06.312049548, 997.3 MHz, 0 threads, 0 threads, 86.5 %
08/08/19 03:37:06.327400194, 986.8 MHz, 0 threads, 0 threads, 0 %
08/08/19 03:37:06.341924187, 992.2 MHz, 0 threads, 0 threads, 85.8 %
08/08/19 03:37:06.362272585, 949.4 MHz, 0 threads, 0 threads, 0 %
08/08/19 03:37:06.376996772, 963 MHz, 0 threads, 0 threads, 92.4 %
08/08/19 03:37:06.397414535, 951.4 MHz, 0 threads, 0 threads, 0 %
```

## Displaying the GPU metrics in the terminal

#	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
	CPUTime	Timestamp	AvgGpuCoreFrequency	CsThreads	DsThreads	EarlyDepthTestFails	EuActive	EuFuBothActive	EuStill	GpuBusy	GpuCoreClocks	GpuTime	GsThreads	HiDepthTestFails	HsThreads	L30Bank3Active	
	(ns)	(ns)	(Hz)	(threads)	(threads)	(pixels)	(%)	(%)	(%)	(%)	(cycles/s)	(ns)	(threads)	(pixels)	(threads)	(%)	
2			2823079733	104105525	0	0	75390	14.59	1.36	31.73	81.3	16528524	1602666	0	262304	0	39.5
3	07/26/19 05:37:12.820524753	28231477250	1144298708	0	0	0	3980	28.73	5.74	63.4	97.46	168282704	16064750	0	31900	0	88.2
5	07/26/19 05:37:12.841712284	282332970250	1124150083	0	0	0	75216	12.72	0.92	28.81	75.17	18151838	16147166	0	237608	0	38.6
6	07/26/19 05:37:12.857142675	282348992666	1066659346	0	0	0	94556	15.38	1.51	30.98	82.35	17603850	16052250	0	282440	0	40.2
7	07/26/19 05:37:12.881702527	282365077750	1096142796	0	0	0	16008	30.68	6.13	57.43	95.85	17647990	16100003	0	46972	0	83.7
8	07/26/19 05:37:12.901611537	282381202500	1145502248	0	0	0	86516	14.27	1.21	28.87	77.02	16463778	16118500	0	266388	0	39.5
9	07/26/19 05:37:12.916787983	282397274083	1137910806	0	0	0	29884	30.06	5.89	50.49	92.69	18249339	16037583	0	91664	0	76.1
10	07/26/19 05:37:12.936550282	282413342166	1145402719	0	0	0	81900	14.29	1.2	28.8	76.59	18393007	16058166	0	260008	0	39.4
11	07/26/19 05:37:12.957188950	282429370416	1117106208	0	0	0	28796	28.74	5.46	50.63	92.18	18014734	16102250	0	95248	0	75.6
12	07/26/19 05:37:12.9719191027	282446165333	1145479490	0	0	0	86636	15.4	1.61	29.37	76.84	19216699	16776083	0	244972	0	40.5
13	07/26/19 05:37:12.971812219	282462277500	1143750330	0	0	0	35016	29.2	5.99	50.03	92.73	18832516	16465883	0	101716	0	74.6
14	07/26/19 05:37:12.987996268	282478761250	1143664701	0	0	0	78360	14.03	1.17	29.23	76.79	18391176	16089916	0	252964	0	39.4
15	07/26/19 05:37:13.015119633	282494864750	1135096612	0	0	0	32480	27.67	5.13	49.82	91.28	18403826	16213416	0	114148	0	73.2
16	07/26/19 05:37:13.022389811	282511701333	1144389215	0	0	0	73024	16.03	1.73	30.34	79.31	19108820	16697833	0	253752	0	41.5
17	07/26/19 05:37:13.048433377	282527729916	1131611210	0	0	0	31280	15.4	5.1	49.62	92.43	18185180	16070166	0	112208	0	74.4
18	07/26/19 05:37:13.064499623	282544403333	1144993981	0	0	0	73890	15.7	1.77	29.82	76.8	19130839	16708250	0	233344	0	40.4
19	07/26/19 05:37:13.081094127	282560512333	1092822304	0	0	0	31216	25.97	4.61	48.67	92.15	17504653	16059750	0	109344	0	71.2
20	07/26/19 05:37:13.106529105	282577273333	1144394525	0	0	0	62376	18.24	2.38	32.16	81.55	19098418	16688666	0	233256	0	44.6
21	07/26/19 05:37:13.108883633	282593264583	1099068972	0	0	0	31744	23.1	3.86	48.04	88.32	17672296	16079333	0	118920	0	67.5
22	07/26/19 05:37:13.138822065	282610053333	974625794	0	0	0	42472	20.2	3.15	37.43	84.29	16391581	16818333	0	148592	0	48.8
23	07/26/19 05:37:13.137119964	282626175500	1032229441	0	0	0	29436	23.29	3.91	50	90.56	17151855	16932333	0	108720	0	69.3
24	07/26/19 05:37:13.152189511	282643456000	966396235	0	0	0	46276	20.34	3.19	38.23	84.63	16129072	16689916	0	137688	0	49.4
25	07/26/19 05:37:13.181725145	282659484000	1015732161	0	0	0	34240	22.92	3.78	49.47	90.32	16331026	16078083	0	97616	0	67.4
26	07/26/19 05:37:13.200498627	282676224000	956763894	0	0	0	40376	21.98	3.52	37.74	84.2	15968708	16990333	0	126756	0	51.2
27	07/26/19 05:37:13.206951584	282692406666	1052251867	0	0	0	29636	24.28	4.11	47.81	90.4	17583867	16780333	0	104588	0	68.4
28	07/26/19 05:37:13.21833034	282709674666	1144395642	0	0	0	53940	19.17	2.76	33.28	79.99	19145453	16729750	0	170312	0	46.6
29	07/26/19 05:37:13.241750305	282725809916	1146157064	0	0	0	42276	22.77	3.64	44.14	86.35	19164796	16729916	0	115396	0	64.8
30	07/26/19 05:37:13.252025990	282731333333	1144397674	0	0	0	53436	19.77	2.9	33.78	81.39	19140226	16727250	0	160052	0	48.2
31	07/26/19 05:37:13.281744472	2827592561416	1102203042	0	0	0	31636	23.53	3.91	48.91	90	18432000	16723416	0	97000	0	69.2
32	07/26/19 05:37:13.306383005	282776576000	1007951418	0	0	0	45780	19.29	2.86	37.05	84	16819265	16685883	0	124572	0	47.7
33	07/26/19 05:37:13.306893551	282792672750	1118828807	0	0	0	38120	23.48	3.83	45.46	88.77	18756139	16764083	0	106048	0	66.2
34	07/26/19 05:37:13.341189866	282810246666	1145583746	0	0	0	50284	19.54	2.88	33.9	81.06	19220413	16777833	0	147492	0	47.4
35	07/26/19 05:37:13.341551373	282826142333	1146729533	0	0	0	34804	24.66	4.18	46.2	88.99	19119230	16672833	0	97644	0	68.8

## Collecting the GPU metrics in a CSV

After analyzing the metrics, we had to feed the metrics given by these programs to a Python program so the model could have access these metrics. For this task we chose to use named pipes as the programs were on a local machine.

To maximize speed, the I/O operations were done with a C extension which allows Python to execute C code. Which improved the python I/O operation from 25 ms to .2 ms.

To analyze the current existing control mechanism used by the chip we looked into certain registers that gave us an insight on this. Along with the per core frequency, per core temperature, the power usage of the chip, log bits that would track when a certain control mechanism was triggered as well as 100+ other metrics, we were able to gain an insight on this control mechanism.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TimeStamp	Power	cpuFreq1	cpuFreq2	cpuFreq3	cpuFreq4	cpuFreq5	cpuFreq6	cpuFreq7	cpuFreq8	ThermalStatLog	PROCHOTLog	CritTempLog	ThermalThresholdLog	ThermalThresholdLog	PowerLimitNotLog	cpuReadout	cpu1Readout	cpu2Readout	cpu3Readout
02:04:04.049703	1.87999207214349	3002.477	3985.686	3676.378	3900.594	3730.518	3821.951	2431.525	1900	0	0	0	0	0	0	29	30	28	28
02:04:04.149660	6.92671534306861	3387.794	3798.832	3663.336	2704.224	2267.945	1942.114	1900.594	1900	0	0	0	0	0	0	29	29	29	28
02:04:04.159738	3.87983726929946	1900.097	1900.445	1900.62	1899.939	1900.016	1900.352	1900.602	1900	0	0	0	0	0	0	29	29	29	28
02:04:04.169863	5.46643632773939	2365.524	1900.445	1900.62	1899.939	1900.016	1900.352	1900.602	1900	0	0	0	0	0	0	28	29	29	28
02:04:04.179863	5.00787087775232	2937.878	2655.597	2698.11	2856.379	2717.434	2668.351	2671.861	2546.938	0	0	0	0	0	0	28	29	28	28
02:04:04.189890	5.64769782738888	2937.878	2655.597	2698.11	2856.379	2717.434	2668.351	2671.861	2546.938	0	0	0	0	0	0	28	29	28	28
02:04:04.199891	5.702355209438	3983.383	3853.97	3672.487	3873.664	3641.557	3807.051	3849.121	3839.275	0	0	0	0	0	0	28	29	28	28
02:04:04.209985	5.96903136440091	3899.935	3900.675	3901.31	3900.582	3900.015	3902.011	3901.763	3901.262	0	0	0	0	0	0	28	29	28	28
02:04:04.220029	4.894836523126	3522.833	3900.675	3901.31	3900.582	3900.015	3902.011	3901.763	3901.262	0	0	0	0	0	0	28	29	28	28
02:04:04.230037	3.2899553223388	2924.665	3271.553	3262.335	3144.293	3206.721	3271.128	3305.969	3305.917	0	0	0	0	0	0	28	29	28	28
02:04:04.240158	2.70722546209251	2233.591	3271.553	3262.335	3144.293	3206.721	3271.128	3305.969	3305.917	0	0	0	0	0	0	28	29	28	28
02:04:04.250398	3.01654860604866	2100.08	2125.477	2141.043	2139.109	2216.483	2153.488	2109.217	2124.194	0	0	0	0	0	0	28	29	28	28
02:04:04.260323	2.36467179538415	2100.08	2125.477	2141.043	2139.109	2216.483	2153.488	2109.217	2124.194	0	0	0	0	0	0	29	29	28	28
02:04:04.270440	2.17986179664363	2100.085	2100.039	2100.478	2100.431	2100.012	2100.363	2100.271	2100.58	0	0	0	0	0	0	29	30	28	28
02:04:04.280518	2.12410714285714	2100.004	2100.401	2100.257	2100.398	2100.003	2100.382	2100.312	2100.493	0	0	0	0	0	0	29	30	29	28
02:04:04.290660	2.1036553256478	2100.068	2100.467	2100.853	2100.411	2099.995	2100.402	2100.392	2100.248	0	0	0	0	0	0	28	30	28	28
02:04:04.300818	2.97103461958139	2100.08	2100.159	2100.009	2100.411	2099.995	2100.402	2100.392	2100.248	0	0	0	0	0	0	28	30	28	28
02:04:04.310805	15.4195117109964	2100.08	2100.159	2100.009	3283.735	2617.834	3477.409	3809.174	3033.542	0	0	0	0	0	0	28	29	24	24
02:04:04.320951	17.18947415959342	3801.721	3847.746	3909.057	3677.311	3940.498	3758.023	4087.069	3637.056	0	0	0	0	0	0	27	29	24	24
02:04:04.330983	18.8795157406494	3801.721	3847.746	3909.057	3677.311	3940.498	3758.023	4087.069	3637.056	0	0	0	0	0	0	27	29	25	24
02:04:04.341209	19.107062174639	3802.688	3882.074	3874.781	3737.506	3884.281	3563.458	3614.458	3889.929	0	0	0	0	0	0	27	29	27	27
02:04:04.351202	13.9561891515994	3802.688	3882.074	3874.781	3737.506	3884.281	3563.458	3614.458	3889.929	0	0	0	0	0	0	27	28	26	26
02:04:04.361209	6.72858404725622	3780.477	3523.266	3879.938	3789.638	3783.851	3685.003	3692.837	3782.254	0	0	0	0	0	0	27	29	27	27
02:04:04.371258	7.11363184079602	3993.71	3935.177	3940.596	3977.402	3984.908	3925.881	3943.15	3959.033	0	0	0	0	0	0	27	29	27	27
02:04:04.381465	13.6748047840269	3909.221	3941.278	3988.731	3900.392	3943.679	3969.289	3913.073	3900.286	0	0	0	0	0	0	27	28	23	23
02:04:04.391675	15.0861598132085	3567.876	3760.741	3797.203	3450.679	3611.529	3697.653	3792.555	3625.764	0	0	0	0	0	0	27	28	25	25
02:04:04.401574	19.2212592149831	3567.876	3760.741	3797.203	3450.679	3611.529	3697.653	3792.555	3625.764	0	0	0	0	0	0	27	28	24	24
02:04:04.411878	21.4193453547628	3559.461	3194.865	3380.021	3434.495	3533.709	3577.889	3636.21	3628.904	0	0	0	0	0	0	27	28	24	24
02:04:04.421733	16.2366214057908	3559.461	3194.865	3380.021	3434.495	3533.709	3577.889	3636.21	3628.904	0	0	0	0	0	0	26	28	26	26
02:04:04.431840	13.9107990506329	3714.946	3810.122	3871.78	3840.932	3571.301	3624.645	3473.165	3688.423	0	0	0	0	0	0	27	28	27	27
02:04:04.441866	16.8944549545409	4073.641	3900.346	3900.419	4057.694	4169.766	3901.507	3900.384	4113.646	0	0	0	0	0	0	26	28	26	26
02:04:04.451887	16.3149441340782	4037.641	3900.346	3900.419	4057.694	4169.766	3901.507	3900.384	4113.646	0	0	0	0	0	0	26	28	26	26
02:04:04.461888	16.9485102979404	4072.122	3929.398	3911.583	4000.759	4129.45	3912.704	3933.485	4145.777	0	0	0	0	0	0	25	28	26	26
02:04:04.471956	6.58952494872533	4072.122	3929.398	3911.583	4000.759	4129.45	3912.704	3933.485	4145.777	0	0	0	0	0	0	26	28	27	26
02:04:04.482215	20.122905578531	3628.667	3231.909	3466.938	3470.288	3864.652	3435.851	3482.989	3484.867	0	0	0	0	0	0	25	27	25	25
02:04:04.492283	21.0253526684423	3628.667	3231.909	3466.938	3470.288	3864.652	3435.851	3482.989	3484.867	0	0	0	0	0	0	25	27	25	25
02:04:04.502359	23.195558838414	3744.185	3433.613	3686.053	3722.743	3876.314	3642.44	3796.319	3796.929	0	0	0	0	0	0	25	27	24	24
02:04:04.512415	19.5486571181208	3881.723	3777.468	3837.048	3881.661	3892.056	3869.289	3876.096	3900.402	0	0	0	0	0	0	25	27	26	26
02:04:04.522402	13.823170317073	3881.723	3777.468	3837.048	3881.661	3892.056	3869.289	3876.096	3900.402	0	0	0	0	0	0	25	27	26	26
02:04:04.532617	16.3473497189852	3712.15	3356.957	3820.182	3550.77	3891.63	3702.028	3503.959	3623.125	0	0	0	0	0	0	26	27	25	25
02:04:04.542575	19.7762231956197	3712.15	3356.957	3820.182	3550.77	3891.63	3702.028	3503.959	3623.125	0	0	0	0	0	0	25	27	24	24

CSV file generated by the Python program created to monitor these metrics

To control the CPU frequency, we switched the CPU governor to user mode. This allowed user created programs to change the CPU frequency. Along with frequency modulation to control the duty cycle we were able to gain a high precision of control of the CPU frequency.

### 3. CULTURAL EXPERIENCE

#### 3.1 Beijing

This summer the team went to Beijing to do research and cultural exchange. As the capital city of the People's Republic of China, Beijing is the second largest Chinese city by urban population and the center of culture and education. Beijing has been China's capital for eight dynasties, including the Qin, Jin, and Qing dynasties. Due to its rich history, Beijing has many antique buildings and beautiful streets that are famous and worth visiting. For instance, the Summer Palace, which we visited the first weekend, was built during the Qing dynasty and has been preserved ever since. On top of that, the Great Wall of China serves as not only a global landmark but also a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site.



Wudaokou



Cole on the subway

While in Beijing, the team realized that Beijing is a popular destination for tourists from all over the world. This is due to the enticing juxtaposition of the historic and modern. In addition to its rich cultural history, Beijing has many Western influences. Throughout our time in Beijing, we recognized popular Western restaurants and stores including McDonalds, Burger King, Walmart, and Pizza Hut. The large majority of local restaurants have English translations on their menus, and most cashiers and employees in the local stores could speak enough English to accommodate us.



### 3.1.1 Tiananmen Square

Tiananmen Square is a city square in the centre of Beijing, named after the Tiananmen which means the Gate of Heavenly Peace. Tiananmen Square contains the Monument to the People's Heroes, the Great Hall of the People, the National Museum of China and the Mausoleum of Mao Zedong. The square is famous as it is where Mao Zedong proclaimed the founding of the People's Republic of China on October 1, 1949. This makes Tiananmen Square a popular destination for tourists.



Chairman Mao Zedong



Inside the Square

There was a large amount of people waiting in line to enter Tiananmen Square when our group arrived by subway. The foliage was well kept and the entrance was well protected by security guards. Inside the square, we saw lots of vendors in the public area, and gated off to the side was a military training area. We didn't stay very long that day but we made sure to come back a few more times to see all the attractions in the area.

### 3.1.2 Forbidden City

The Forbidden City is located right behind Tiananmen Square. In fact, Tiananmen is the gate and main entrance to the Forbidden City. Both places

boast traditional Chinese architecture. Historically, the Forbidden City was the imperial palace for the Ming Dynasty and Qing Dynasty. For almost half a century, the Forbidden City served as a home for emperors and their subordinates. The site consists of over 980 buildings and spans the distance of 180 acres. Nowadays, the Forbidden City is better known as the Palace Museum, and allows visitors to explore the corridors of what was once China's most restricted palace.



Carson on the Main Bridge



One of the Interior Corridors

All the buildings in the Forbidden City are topped with a yellow roof, signifying royalty and holiness. Many of the buildings feature dragon statues and designs, since the dragon was considered the king of all animals. Similarly, the emperor's wife was represented by a phoenix, since the phoenix was believed to be the queen of all animals.

### 3.1.3 Summer Palace

Historically, Summer Palace is where the rulers of China would spend their summer vacations. It is located in Northwest Beijing and only a short subway ride away from Tsinghua University. This was our very first cultural

outing. This was also our first time riding the bus. Being one with the bus regulars was both a humbling and unique experience.



Winson looking down



View from the top level

The Summer Palace was a site to behold. The palace was built on top of a hill and overlooked a magnificent lake, dotted with small tourist boats. As we walked the brick path up to the palace, we saw lots of interesting street performers, including painters, dancers, and instrumentalists. Once we reached the palace, we were amazed by how the traditional Chinese architecture was so grand yet so detail-oriented. We explored all the different levels and enjoyed the panoramic view from the top.

### 3.1.4 Nanluoguxiang

Nanluoguxiang is a traditional Chinese street dating back to the Yuan Dynasty. Despite being hundreds of years old, the street is now filled with countless different shops and eateries. Many restaurants have glass walls so people outside can watch the cooks in action. Some of our favorite places here included a cat-themed pet shop, a mango drink shop, a food market featuring takoyaki, a metal-works shop, and several shops specializing in souvenirs. We walked around for a couple hours admiring the busy culture, almost feeling as if we time-traveled to a different century.



The main street



One of the indoor food markets

Fortunately for us, we had the chance to come back. Nanluoguxiang is located right next to Tiananmen Square, so we made sure to swing by for more delicious food when we visited Tiananmen Square.

### 3.1.5 Great Wall of China



Sections of the Great Wall

The Great Wall first began construction under the Qin Dynasty by the order of Qin Shi Huang in hopes of establishing a centralized rule and to prevent the resurgence of feudal lords. After the Qin Dynasty was destroyed and the Han Dynasty assumed power, the project of the Great Wall was abandoned. Many years later under the Ming Dynasty, the emperor resumed the construction of the Great Wall in order to protect China from Mongolian invasions from the North.

Due to its rich cultural history, the Great Wall of China was an absolute must-see for us on this trip. The Great Wall can be visited at many of its locations, but we decided to visit the Great Wall at Badaling because it is the closest location to Tsinghua University. In order to get there, we first biked to the subway station, rode the subway to the train station, and then rode the train for about three hours. We were fortunate to be there on a day with overcast weather, meaning cooler temperatures but also higher traffic. The journey to get there was long, and the lines were packed with tourists from across the globe, but our patience was well worth it in the end. We decided to explore the North portion of the wall, which had about 12 towers and their connecting paths available for tourists to walk on. We were actually surprised by the level of physical intensity needed to hike up the winding stairs of the wall. The wall was very steep in many parts, but the high climbs only made the views more gorgeous. From one side of the wall, we could make out the city with its impressive towers. From the other side, we saw endless green mountains shrouded in fog. In all, we spent about four hours hiking along the wall, some of the most memorable hours of our entire trip.

### 3.1.6 National Museum of China



The National Museum of China was located right across from Tiananmen Square. We waited in a long line outside, which was filled with many street vendors. There were many security checkpoints we had to go through before being permitted to enter.

Upon entry, we decided to first visit the Historical China exhibit. We saw lots of fossilized remains of ancient China, including pottery, weapons, money, and art. We were very impressed with how well the items were preserved, since some dated back thousands of years. Our favorite exhibit, we all agreed, was one displaying all the gifts that China received from other countries. Each gift was unique and fascinating in its own way, many being intricate art pieces or weaponry plated with precious metals. There were other exhibits we didn't get the chance to see, notably the immersive tour of Van Gogh, due to the museum's sheer size we did not have the time to explore it all.

### 3.1.7 Yuyuantan Park



Yuyuantan Park is one of the major urban parks in the city of Beijing. The park covers a territory of over 100 acres, a large amount covered by its main lake. The history of Yuyuantan dates back to the Liao Dynasty (907 - 1125 AD) and the Jurchen Jin Dynasty (1115-1234). Beijing was the secondary capital city of both these dynasties. As the years went by, the lake was created by irrigating spring water, and the palace was eventually abandoned. Nowadays, it is popular for its vast amount of cherry blossom trees and boating opportunities out on the lake. We came here specifically for the latter, and had a peaceful afternoon peddling our boat across the lake.

## 3.2 Tsinghua University



Main Building - where we worked!



Island on campus

Tsinghua University is one of the top universities in China and is especially famous for its engineering programs. The campus is so large that it resembles a small city. It has multiple banks, supermarkets, electronic stores, parks, hair salons, over 23 cafeterias, and anything else someone living on campus could possibly need. There are several malls and shopping centers located right outside campus, along with skyscrapers belonging to Google, Sohu, and other big companies. Since the campus is too large to cover by foot, most people choose to ride bikes or mopeds. Outside most buildings you will see hundreds of bikes parked.

### 3.2.1 Apartment

Our apartment was in the South East part of the Tsinghua campus. The apartment we lived in had two bedrooms, a living room, a bathroom, a kitchen, a balcony to hang clothes and a small common area. Since there were three of us, we rotated who slept in the living room over the 9 weeks. Our apartment had a water boiler to sanitize the water since the water in China is not safe to drink. We had internet but had to pay 2 RMB for every gigabyte we were using. We ate out at the canteens or brought food home so we did not ever cook inside the house. The bathroom was interesting as there was no tub but simply a drain in the bathroom floor for the shower water to drain into.



### 3.2.2 Lab



Our team was assigned to work in the East Main Building that was located next to the Main Computer Science & Engineering Building. The building is about a ten minute bike ride from our apartment. In the lab, each person on the team had their own cubicle alongside many Tsinghua students. Everyday during lunchtime, the team would go out and eat at one of the campus canteens, or sometimes get food delivered. Every Friday, the whole lab would bike to the on-campus Gas Filled Membrane Gymnasium to play badminton and ping pong. It was one of our favorite activities to do in China and allowed us to bond with the PhD students that worked in the lab.



Cole on the badminton court



## 4. ACKNOWLEDGEMENTS



### **Professor Sheldon Tan**

We would like to thank Professor Tan for coordinating the IRES program and giving us the opportunity to research at Tsinghua. Prior to the trip, Professor Tan let us work as research assistants in his lab. During this time we learned more about the research we would be doing in China and what to expect during the trip. After arriving in China, he met us at the airport and made sure we got to campus safely. Professor Tan's help during the beginning weeks made the transition to living in Beijing much easier for us all. Without the support of Professor Tan, we would not have had this amazing opportunity to participate in research and experience Chinese culture firsthand.

### **Professor Wenjian Yu**

Special thanks to Professor Yu for letting us work in his lab. He was kind enough to give us our own cubicles to do research in. He provided our apartment, sponsored our Chinese Visas, and was always there when we needed him. He gave advice at the weekly meetings when we would review what we have accomplished over the week. We can not thank him enough for making us feel at home at Tsinghua.



### **Sheriff Sadiqbatcha**

We are grateful to Sheriff for leading our group during the trip. Sheriff was very knowledgeable and would guide the direction of the research projects. With his expertise it was easy to start working and we could go to him if we ran into any issues. Outside of the lab we would explore the city and try many different types of food. Sheriff was a great person both in and out of the workplace and over the duration of the trip we made many great memories together.



### **Barry Xie**

Thank you to Barry Xie for taking us to many popular destinations around Beijing on the weekend. He served as a translator and helped us communicate

with the locals. He took time out of his busy schedule of research to help us navigate the city safely and without him we would have surely gotten lost in the first few weeks in Beijing. He helped us get subway cards and even showed us some of his favorite restaurants around Beijing.

## **5. CONCLUSION**

Our stay in Beijing has truly been a once in a lifetime experience. The time spent in Professor Yu's lab at Tsinghua gave us a preview into how life would be if we pursue higher education. We were able to see progress on the research project through the work we did in the lab. During the program we could apply the knowledge we learned as students to an outside real world project. We gained experience in using Python and the extensive supported libraries for the programming language.